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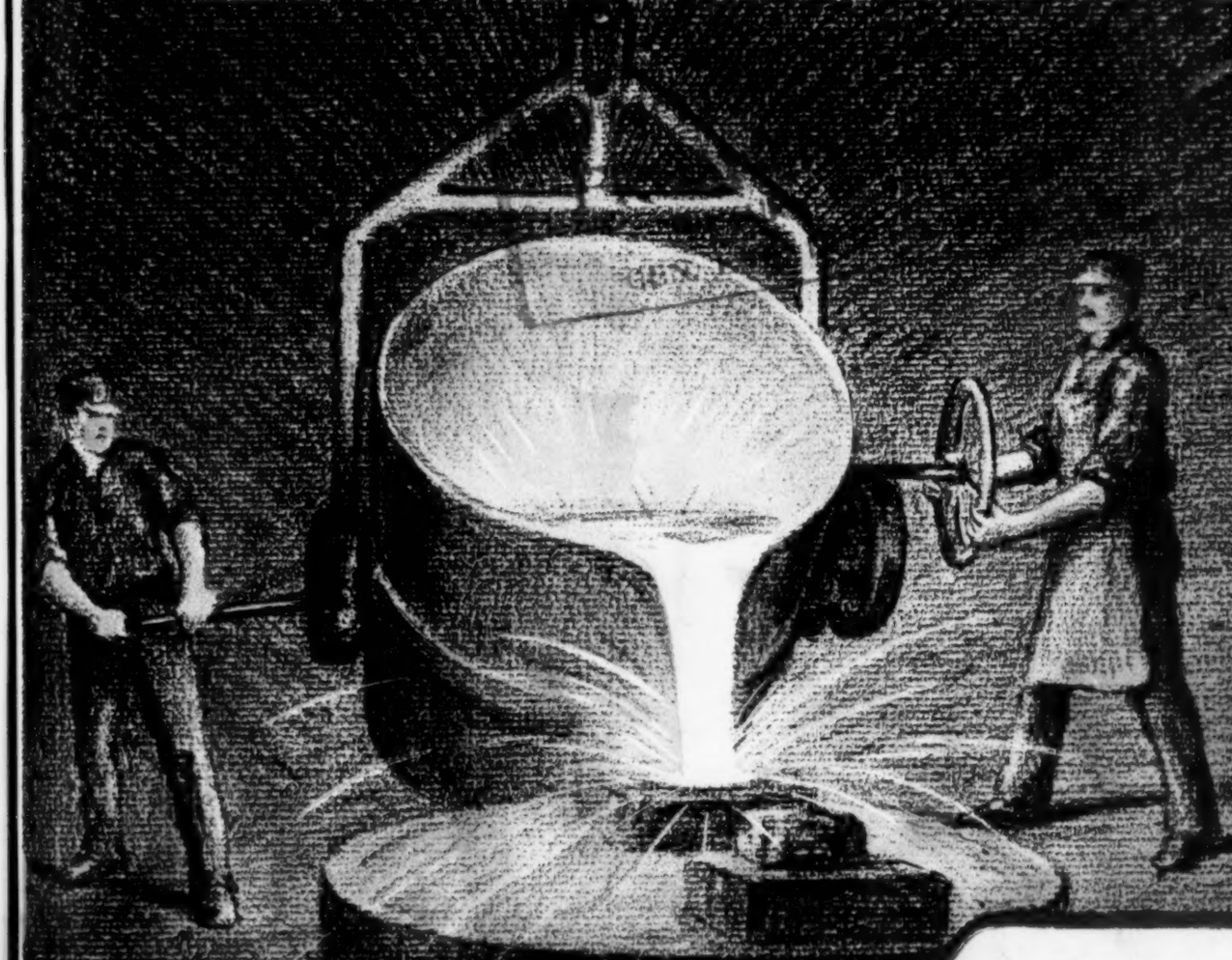
CHEMICAL & METALLURGICAL ENGINEERING



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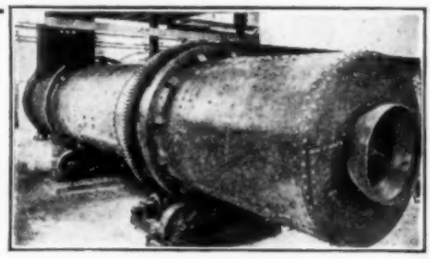

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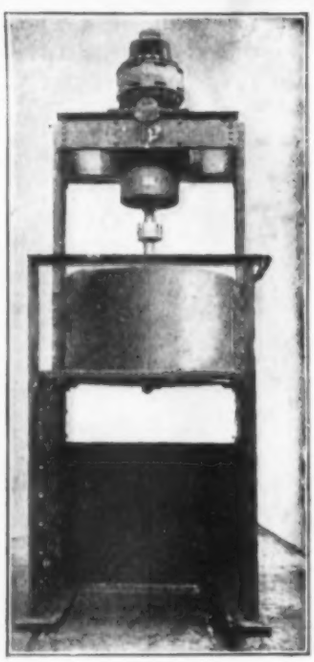

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The Spirit Of the West

IN SPITE of much of the unimpressive "boosting" that is indulged in by the estimable inhabitants of the cities on our Pacific Coast, a visitor among them is constrained to admire the ingenuity, resourcefulness and energy displayed in their industrial and commercial life. One may not be deeply moved by stories of the rising values of real estate, but he cannot escape the conviction that potential wealth in water power and raw material exists in greater concentration in that western empire than in any other part of the country. Handicapped though it may be now by sparsely settled areas, light local demand for its own wonderful resources and immense distances from present domestic markets, this region is nevertheless the one toward which industry and commerce in the United States must ultimately grow.

And not to meet domestic needs alone, but to supply foreign markets as well; for despite the fact that the people of the United States have, or had before the war, little or no international sense and vision, dwellers on the Pacific Coast have a lively sense of international trade and world business. Looking east they face their own country, but to the west is another world teeming with potential consumers of the products of our civilization, and prolific in natural and artificial commodities that will find a ready market here. Like the Atlantic Coast of our country, the Pacific has a double outlook and is just beginning to develop its possibilities.

Its industry is growing impressively. Climate and cheap hydro-electric power developed by the municipality are responsible for the recent location of an immense rubber factory in Los Angeles. Harbor and shipping facilities are making of San Francisco the great port of the Pacific Coast. Portland, though an inland city, is developing an export and import trade; while the two cities on Puget Sound, Seattle and Tacoma, are centers of world-wide trade in edible oils and copper. Notable is the fact that fixation of nitrogen by the arc process is practiced only in our great Northwest, where water power is cheapest, and electric smelting of iron ores is giving promise of developing there into a stable industry.

In short, engineering and technical developments are the substantial things that impress the visitor, even though they are not most often "boosted." But even the "boosting" can be condoned on the score that it creates and supports a spirit of civic loyalty too often lacking in Eastern communities, and is in some degree expressive of that Western hospitality that is as large as the great out-of-doors and which does not find its counterpart elsewhere in the country.

President Signs Water-Power Bill

ANNOUNCEMENT was made at the White House on the 18th inst. that the President had signed the water-power bill on the 11th, within ten days from the time it was delivered to him. The provisions of the bill, outlined elsewhere in this issue, are accordingly the law of the land. In spite of the fact that it was necessary to support the legality of the President's act by a technical interpretation of the Constitution by the Attorney-General, it is not believed that this will have any effect in delaying actual development of water power. Money is now the most necessary item. Had Secretary PAYNE been less solicitous regarding possible damage to our national parks through water-power development, the delay need not have occurred and the bill could have been signed before Congress adjourned. Mr. PAYNE'S reported anxiety regarding the parks was unimpressive and his eleventh-hour conversion unconvincing. One could have wished that Mr. LANE were still Secretary of the Interior. No one had a higher appreciation of our national parks than he; but that did not warp his judgment of the value of water-power development.

Developments in Flotation Litigation

ELSEWHERE in this issue we publish two items relative to the litigation between Minerals Separation, Ltd., and the Miami Copper Co. One relates to a motion by the defendant in the United States District Court at Wilmington to dismiss the petition of the plaintiff seeking to punish the defendant for contempt of court. The other announces the order of the United States Circuit Court of Appeals, Philadelphia, refusing to grant the Miami company's petition to reopen the case to admit newly discovered evidence.

It is a mere coincidence that these two items appear in the same issue, as they are not directly connected with each other. There is, however, a certain relation, since the Circuit Court of Appeals virtually remands the subject matter of the Miami petition to the accounting proceedings before the Master, whereas the petition of Minerals Separation, Ltd., seeks to remove questions at issue from the accounting.

Unfortunately the original decision of the Circuit Court of Appeals in the Miami case stops short of what is, for the general mining public, *the* important question, namely, whether the use of the pneumatic cell itself is, or is not, an infringement of patents. The reopening of the case would have permitted a more prompt adjudication of the question in its broadest sense. However, in the last analysis the determination of this point by the Master will have the same effect, as it will then come by appeal before the same court.

Where Are The Chemists?

SURPRISE was expressed by one delegate to the organizing conference of the Federated American Engineering Societies that the chemists were not more largely represented on the floor. Invitations were sent to a long list of engineering and allied technical associations, and yet the American Chemical Society—the most numerous body of chemists, more or less technical—did not send deputies. However, the matter was briefly dismissed by the statement that chemists are not engineers.

Holding the opinion that the Chemical Society should have been represented, it is not so easy to excuse absence in that manner. Risking the chance of tedium, a few thoughts on the relationships of the numerous engineers served by CHEMICAL & METALLURGICAL ENGINEERING will be advanced.

"Engineering" has been defined by enthusiasts to be as all-embracing as the official statement of scope of the Bureau of Standards: "The establishment of standards of measurements, constants, quality, performance and practice"! A like blanket definition is that which regards engineering as "the art of organizing and directing men and of controlling the forces and materials of nature for the benefit of the human race." Evidently a sailor and a surveyor are both included—the wide reaches of engineering includes Generals GORGAS and GOETHALS!

Obviously a more restricted meaning corresponds with usage, despite the enthusiasts. An engineer is rather an applied physicist, he who understands the laws of heat, electricity, light, sound, dynamics and statics and can make them useful to man in structures and machines. In this way the sailor and General GORGAS—indispensable though they be—are evidently and properly not classified with the surveyor and General GOETHALS.

Now, is a chemist, "versed in the science of the composition of substances and their transformations," an engineer in this sense? If the chemist is a scientist—one intimate with the systematic knowledge of his subject—he evidently is not called an engineer, and rightly so; and it would be no less than a calamity to revise educational methods so that nearly all the students would graduate chemical engineers, to the exclusion of chemists. On the other hand, if he is more the artist—one whose knowledge is made efficient and useful to his neighbors by skill—then he would be welcomed into their fraternity by all engineers. Dr. STIEGLITZ, evidently, is a chemist primarily, and in no sense an engineer; he is a scientist. Dr. LITTLE, on the other hand, is an engineer primarily, even though well versed in chemistry—he is skilled in the art and science by which the properties of matter are made useful to man through structures and machines. "Properties of matter" is evidently a broad term—so is engineering a broad profession. Both are subdivided by using qualifying adjectives—an electrical engineer applies electrical properties of matter to useful ends, a chemical engineer applies chemical properties of matter to useful ends, a metallurgical engineer applies chemical and physical properties of metals to useful ends.

No apology is needed, then, to most of our readers for devoting much space to the Federated American Engineering Societies, whose object is to further the interests of the public through the use of technical knowledge and engineering experience as applied to political economy, and to consider and act upon matters common to the engineering and allied technical professions. It seems most fit that engineers—a group of educated men distinguished from scientists principally because the engineer applies science for human benefit—it seems most fit that they should organize to further, collectively, the interests of the public.

By the same token, it seems incongruous that the American Chemical Society should lag behind the lead of the American Electrochemical Society and the American Institute of Chemical Engineers in its interest in the Federation. It is true that a large proportion of its members is interested in chemical research, chemical theory, or chemical activities very distantly related to industry—but so are numbers of men in the smaller Electrochemical Society. On the other hand, both associations have many members who are distinctly engineers, and many more members whose work—even though it be of the humblest routine variety—is intimately connected with industrial and engineering enterprise. Does not the American Chemical Society publish a *Journal of Industrial and Engineering Chemistry?* Evidently the interest in the society is quite strong to warrant a publication entirely separate from its scientific annals. Then why do they not act like engineeers and electrochemists? The work ahead is big enough so that there is room for all engineers and allied and associated spirits, and hard enough to need all possible shoulders to the wheel. If the American Chemical Society desires to function in public affairs—and we know it has been urging individual chemists to do so—then why has it not embraced this opportunity to join in the creation of a body for that very purpose?

Synthesis and Analysis Of Engineering Formulæ

OF RECENT years the mathematical laboratory has come to be as thriving a workshop as any other place set apart for scientific investigations. As long as bridges and great structures have been designed, the study of lines of force, as theoretically developed in the science of statics and dynamics, has been of fundamental importance. Engineering of every kind has been dependent on the mathematical development of the pure science with which it was concerned. In a way, next to being able to apply known formulæ in an intelligent manner, the greatest asset of an engineer is to be able to synthesize new ones himself or reverse the operation and analyze any that may be presented to him by others.

In this issue we have a mathematical development that should have an important bearing in a number of directions in technology. It will have to be further developed before it will give the distillation engineer a full set of implements for the solution of his problems, but as it now stands it fills a very large gap that has prevented any considerable progress in the direction of applying mathematics to the consideration of saturated vapors. It may now be expected that the lesser devious ways of partial pressures and Raoult's law may be put on a practical mathematical basis, and give the much-needed formulæ for the calculation of distillation problems.

In connection with the formulæ developed by Mr. WILLIAMSON and the method given at the conclusion of the article for facilitating calculations, it should be mentioned that this year is the three hundredth

anniversary of the logarithm scale, which was invented by GUNTER, an engineer, only six years after NAPIER had conceived the idea of logarithms. Many years passed before the slide rule was brought out and still many more before the alignment chart was developed to give a convenient means of using GUNTER'S log scale. GUNTER used a draftman's compass. In all probability there is as much opportunity today for us to improve on the application of this scale as there was in GUNTER'S time. It is hoped that every reader has at least a small corner in his mind for his mathematical laboratory and that he does not neglect to use it in the study of either pure or applied science.

Organized Labor And the Public

BEFORE President WILSON'S first Industrial Conference last October, it was remarked in some quarters that organized labor was on the defensive, and would have to occupy that attitude at the coming conference. No such attitude was taken, however, by Mr. GOMPERS and his associates and the conference broke up.

A good bit of water has passed the mill since that time. The public has been taking more and more interest in the subject of organized workers and unorganized workers and is rapidly coming to recognize its numerical superiority. Mr. GOMPERS has helped the public to an appreciation of the situation and of his own position in many ways, and particularly so by his delayed attempt to answer Governor ALLEN'S question whether in an industrial dispute the public has no rights. Mr. GOMPERS had to take time to reflect and after he had taken the time—we do not answer for the reflection—he said a number of things not precisely to the point. One that is readily recalled was in substance that every worker must get at least $2,500 a year first.

The obvious rejoinder to Mr. GOMPERS' denial of the public having any rights in an industrial dispute is to inquire how it would be if the shoe were on the other foot—if it were a case of a lockout instead of a strike. Mr. GOMPERS should reflect that the ins sometimes become the outs. The public certainly would not stand for an unreasonable lockout, nor is there any prospect of any large employer at any time undertaking an unreasonable lockout. One wonders—or rather one does not need to wonder—what the attitude of the people would be if a large trolley company were to discontinue its service for a while in order to induce its employees to work for lower wages.

There is likely to be a new reaction in the public mind. The doctrine has been preached everywhere that the "vicious circle" of advancing wages and advancing cost of living, turn about, will get us nowhere. The public has not yet reflected sufficiently upon the proportions of the total number of workers that are, respectively, organized and unorganized. The proportions are approximately 10 per cent and 90 per cent, and for the substantial accuracy of these figures ample proof can be furnished by intelligent interpretation of the last census report showing those engaged in gainful occupations, with allowance for increase in population meanwhile, and the number, not of union workmen, but of the membership claimed by the labor unions.

There will be an important mental reaction when the public comes more fully to consider the proportion of one organized worker out of every ten, and the dictum that has been preached that there is a vicious circle. The alleged vicious circle would get us nowhere, but if one-tenth of the population attempts to better itself at the expense of the ten-tenths, being willing to pay its one-tenth of the tax by virtue of the nine-tenths it escapes, then there is another case altogether.

The public is also coming to a clearer realization of the psychology of the labor unions, that in order to keep things going the leaders must be continually promising the rank and file additional things. There is no stopping. The leaders cannot thrive on past accomplishments, but must continually suggest new goals to be reached. In other words, the union leaders can never get things fixed up satisfactorily, and when the public realizes, as perhaps it will, that this is the situation, it is likely to exclaim "What's the use!" Such a reaction, also, would greatly help in putting things where they belong.

Horse Thieves Among Chemists

IN THE chemical profession as elsewhere there are unfortunately a few unethical persons who take advantage of the general high standing of the collective body for personal aggrandizement or dishonest financial gain. From very early times it has been the desire of scientific men to force such members without the pale.

It is related in the biographical writings of Sir HENRY ROSCOE, as told recently at the Chicago Chemists' Club, that a certain chemist working in a research laboratory obtained exact results as to the atomic weight of the metal under consideration. Sodium, for instance, showed an exact weight of 23. The chief, becoming suspicious, gave him for test a mixture of potassium and sodium, telling him it was sodium. The atomic weight was still proved to be 23. Whereupon this chemist was discharged and, affiliated with the Baptist church, became acquainted with the pastor's servant. One Sunday when she was alone in the house, he bound and gagged her, lifted the family plate and fled to America. He was pursued by the authorities, who located him in the West, but alas, too late, as he had just been hanged for stealing horses.

The procedure is applicable in these times. If the professional career of technical immoralists and pirates is not brought to an end through slow workings of the social laws, a little "Western justice" administered by political action in technical societies will not come amiss.

How Consulting Chemists Secure Clientele

A MANUFACTURING chemist once asked, "How do these consulting chemists get business?"

In Chicago there lives a genial chap, gray with years, young in mind, who prospers because he is loved by all who know him. Aside from being a chemist he is a soul of large understanding, a man among men. He lives in his work and delights in the association of those who come within his ken. He is ever ready to assist the younger ones in the pursuit of paths chemical. He's a regular fellow in his own quiet way. He follows ideals, *not* dollars. It is a privilege to enter his office.

So business just comes into his office, for men trust him. The answer is just there—the human touch by an honest hand is the best business getter.

Readers' Views and Comments

Effect of Insulation on Resistor Temperatures

To the Editor of Chemical & Metallurgical Engineering

SIR:—On page 661 of your issue of April 7, you presented an abstract of an article by W. A. Gatward on Nickel-Chromium Alloys. Referring to wire heating-elements of electric furnaces, the abstract says:

"Experience shows that the presence of a cold body near a certain part of a heating element causes that portion to advance slightly in temperature. If the wire possesses too large a coefficient (temperature coefficient of resistance), this will cause that *portion* to become increasingly hotter until it melts."

The presence of a cold body near a certain part of a heating element can only cool that part, and there is not in such instance any paradox.

However, sudden cooling of a sufficiently large part of the heater will frequently allow the heating current to increase to a value which will burn out another part of the heater. I have often observed this, and the reason for such an occurrence is clear. Of course it can happen only if the element has a positive temperature coefficient of resistance.

A close reading of Mr. Gatward's paper makes it clear that what he had in mind is the local action of a heat insulator, for the presence of an insulating body near a portion of the heater will at times cause the part to burn out—and the insulator may be at first a cold body. That he was not strictly quoted may be inferred from the following verbatim extract from his paper:

"The development of hot spots is very much affected by the temperature coefficient. Another effect of high temperature coefficient is as follows: Imagine a heating unit wound around a muffle as generally used in electric laboratory furnaces. The heating unit is a continuous piece of wire. Suppose that the furnace is operating at 1,800 deg. F. and we place on the floor a fireclay brick. The fireclay brick immediately banks up the flow of heat and the temperature of the wire under the brick rises. This is not a theory but a fact, and the rise is very serious. As the wire under the brick gets hotter its resistance increases. Since the current is the same in all parts of the heating coil, the heat developed, I^2R, will be greater on the floor than on the sides and top. Of course this phenomenon is cumulative and is the actual cause of many burn-outs in industrial devices. The higher the temperature coefficient the more serious this will be."

Mr. Gatward would possibly have been more clear if he had said that by placing a firebrick (or other heat insulator) near the heater, local heating occurs. In this way the editor would not have substituted "cold body" for Mr. Gatward's "fireclay brick." It is not that the brick is cold but that it will not conduct heat very rapidly which is the essential quality.

I had thought that some of your readers would be misled by your abstract which states that "presence of a cold body . . . causes . . . advance in temperature," and have commented on this point because the statement is closely related to the requisites for good furnace construction. One of these is that great care must be taken in applying insulation uniformly, especially when the furnace is to be operated at highest safe temperatures. C. O. FAIRCHILD.

Washington, D. C.

A Rapid Method for the Analysis of Monel Metal

To the Editor of Chemical & Metallurgical Engineering

SIR:—May I make a further suggestion on Mr. Covitz's article which appeared in your magazine, issue of Jan. 7, 1920, p. 31, in regard to the "Rapid Method for the Analysis of Monel Metal"?

In determining the nickel contents, he suggests the usual precipitation with dimethylglyoxime, which in my estimation and experience is a slow process of filtering the resultant precipitate, besides the reagent being an expensive one at the present time.

For the copper content, I plate out my copper from the silicon filtrate by Mr. Covitz's plan. Another weighed sample is dissolved in nitric acid and then driven off with concentrated sulphuric acid, using 10 c.c. Take up with water and heat if necessary to get into solution, cool, then neutralize with ammonium hydroxide. Add about 40 c.c. in excess, also introduce 5 g. of ammonium sulphate. Have bulk of solution about 200 c.c. Connect up to the plating apparatus and proceed to plate out the copper plus the nickel, using three amperes and a revolving cathode whereby one obtains all the copper deposit first, then the nickel, without any interruption whatsoever. The operation of electrolysis usually consumes about one hour.

Strange as it may seem, the nickel does not start to plate until all the copper has been deposited. The combined weights of nickel and copper minus the weight of the copper deposit obtained from the silicon filtrate will, of course, give the nickel content.

The writer has taken copper and nickel salts, also samples of various nickel and copper percentages, and has obtained excellent results by following the scheme as outlined.

If the sample contains cobalt, a correction must then be made, although the writer has never encountered it in monel metal. PAUL W. C. STAUSSER.

Detroit, Mich.

Prosperity of Belgian Artificial Silk Industry

Some Belgian artificial silk works are enjoying prosperity despite the fact that they were victims of the German invasion. Thus the Obourg Artificial Silk Co. reports a profit of 2,142,757 francs for four months' operation in 1919. Work was resumed after ten months' work of restoration, only half the company's installation having been put into service. The other part has been restored and will be in operation soon if supplies of raw material are not lacking. The war damage to the company's property is estimated at 2,500,000 francs, 1914 value.

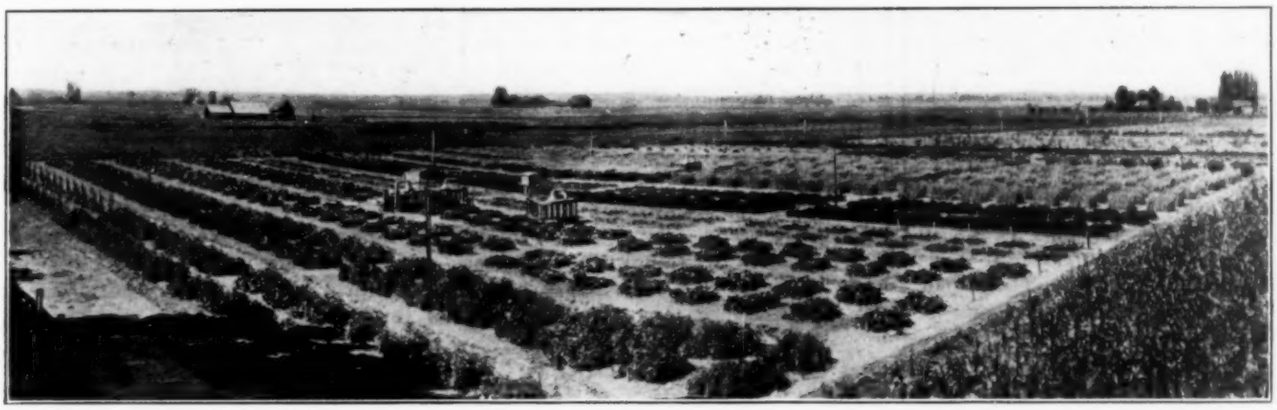


FIG. 1. A. S. & R. CO.'S EXPERIMENTAL FARM

Showing experimental plots of large numbers of common crops for determining effects of SO_2 under varying conditions of light, temperature, relative humidity and stage of growth. During seasons of 1915, 1916 and 1917 more than 3,500 plots were used. Each plot contains 25 sq.ft. and the space allowed for each plant of the various crops is such as should obtain under normal field conditions as determined by good farm practice.

Smoke Litigation in Salt Lake Valley

Notes on the Effects of Smoke Suits and Recent Crop Investigations on Smelting Operations in That Vicinity, the Improvements Made at Murray to Mitigate Nuisances, and the Court's Remarks on the Difficulty of Distinguishing SO_2 Injury

BY ERNEST E. THUM

ANOTHER chapter in the smoke litigation involving smelters operating in the Salt Lake Valley, Utah, was brought to a close on Feb. 21, 1920, when Federal Judge T. D. Johnson signed an interlocutory decree permitting, under certain conditions, the continuance of operation of the American Smelting & Refining Co.'s works at Murray and the United States Smelting Co.'s works at Midvale.

In order properly to appreciate the condition surrounding this decree, it is well to turn back fourteen years or more. At that time Salt Lake City was spoken of as the largest smelting center in the United States, with no less than seven different plants, having a combined capacity in lead and copper ores of 8,000 tons of lead and copper ores daily. These seven were doing the work which a long line of foregoing operators had conducted thereabouts in small smelters since the beginnings of mining in Utah. An enumeration of the plants operating in 1906 follows:

Name of Plant	Kind of Smelter	Capacity, Daily Tons
Murray, A. S. & R. Co.	Lead	1,500
Garfield, A. S. & R. Co.	Copper	1,250
Bingham	Copper	1,000
Midvale, U. S. S. R. & M. Co.	Copper and lead	2,500
Yampa	Copper	500
Highland Boy	Copper	1,000
Utah Consolidated	Copper	250

Before 1906, however, all of these plants, without exception, were operating with little or no regard for the recovery of fume and dust. None of them except the newly built Garfield smelter had an organized flue and stack system; each relied upon small individual chimneys located close to each furnace or department.

In the light of our present information about smoke and fume it is not surprising that under such circumstances quite severe damage was done throughout a considerable area surrounding each of the smelters. Consequently, upon suit of 409 farmers, Federal Judge John A. Marshall, on Nov. 5, 1906, enjoined certain of these smelters from continuing the smelting of ores containing more than 10 per cent of sulphur, except after installing satisfactory means for neutralizing the obnoxious fumes resulting therefrom. Pending an appeal on this suit, the smelters continued operating.

However, the Murray plant of the American Smelting & Refining Co. immediately erected a large baghouse (first operated in July, 1907) for eliminating solid particles from the gas. This was in line with the contention made by some of the smelting companies that the damage was largely due to compounds of sulphur and arsenic which condensed on particles of soot or other solid matter and settled with them to the ground. Naturally, then, if soot and solidified vapors could be filtered out of the smoke, little cause for damage would remain. After making the proper financial settlements with the complaining farmers, the American Smelting & Refining Co. was, therefore, freed from the litigation and was allowed to operate nine or ten lead blast furnaces. In its operations it was also allowed to roast ores containing 25 per cent of sulphur and to smelt ores containing more than 10 per cent, if the average of the furnace charge was no more than 10 per cent sulphur and if, in addition, all furnace gases were baghoused, removing lead, arsenic and other solids. The company also agreed to construct an extensive dust chamber at the roaster department to cool the gases from those operations so as to precipitate all the condensable vapors possible.

The same company's plant at Garfield was situated between the Great Salt Lake and Oquirrh Mountains in such a way that the smoke was not carried over farming lands by the prevailing winds. However, in

order to be doubly safe, the company purchased about 35,000 acres of ground along the lake shore to insure against future smoke litigation by the owners.

The United States Smelting Co., however, was not so successful in its negotiations with the farmers and when, on Jan. 11, 1908, the Federal court's injunction was sustained under appeal, its plant closed. Within a couple of months, however, the company petitioned the court for the right to reopen, claiming that its newly perfected Sprague process of introducing zinc oxide into the smoke would remove all cause for crop injury. At the same time the zinc would neutralize sulphuric acid, forming with it a solid which would be caught by the bags. This would improve the quality of the issuing gases as well as prevent rapid deterioration of the bags themselves. On April 5, therefore, the Federal Judge suspended the injunction and allowed the Midvale plant to operate its lead furnaces, treating 25 per cent sulphur ore up to one-third of its capacity. However, it was stipulated that the plant must also remove all solids from its roaster and blast-furnace gases, discharging all smoke through a single smokestack free of lead, copper, arsenic and antimony compounds and all traces of sulphur trioxide. At the same time its percentage of sulphur dioxide must be no greater than 0.75 per cent. Under such circumstances the plant was allowed to run three years in order to demonstrate the efficiency of baghousing in conjunction with the Sprague process.

As a matter of collateral interest the fate of the other plants in that region is more or less interesting. The Bingham copper smelter was abandoned in December, 1907. For some time there were rumors that a more modern plant would be built and placed upon the south shore of the Great Salt Lake, but these plans did not materialize.

Many Plants Dismantled

On the other hand, there were several meetings between representatives of the farmers and the owners of the Highland Boy plant, in which an agreement was sought. It was reported at the time that the farmers demanded a bonus of $175,000 before they would agree to any modification of the injunction against that smelter, while the company said that $100,000 plus actual damages was its limit. On account of this deadlock, a satisfactory arrangement was made with the International Smelting Co. for ore treatment at a new plant, then under contemplation. The Highland Boy smelter was therefore closed down and dismantled, the best of the machinery being reinstalled by the International company at Tooele. This plant was built at Pine Canyon, where prevailing day winds would carry the smoke into the mountains. Preliminary agreements were made with nearly all the land owners within a three-mile radius that in case smoke damage resulted title to the land would be transferred to the company for a certain stipulated value. The Yampa plant in Bingham Canyon was not involved, being out of the smoke zone. However, its life was relatively short.

Under these circumstances it is seen that the smelters at Murray and at Midvale are the two survivors of the cluster operating in that region in 1906, and disrupted by smoke suits. The so-called Godfrey decree and its subsequent stipulations required the American Smelting & Refining Co. and the United States Smelting Co. to install modern fume-collecting and gas-cleaning devices to efface the evident nuisances existing at that time. Subsequent operation of both of the plants proved satisfactory to the farmers for many years. However, during the period from 1912 to 1916 several complaints were made, and in 1916 another suit was entered against the two smelting companies asking damages and other relief.

Investigating Staffs Maintained

During this time both of the companies have maintained investigating staffs which have not only worked upon the question of smoke injury in general, but have also operated experimental farms nearby the smelters (Fig. 1). It was their practice to have members of their staff investigate complaints as they were made. The American Smelting & Refining Co. in many cases found it best to admit damage by sulphur dioxide and settle accordingly. It is interesting to note that it took some years for both sides to become convinced that fume or other solid was not the *sole* cause of plant injury. However, with the operation of well-designed baghouses, the amount of solid matter escaping from the central stack was of negligible quantity, and yet undoubted discoloration and bleaching of foliage occurred at times. However, the United States Smelting Co. would not admit that SO_2, in the concentrations caused by their operators, caused any economic damage—that is, deteriorated the crops in quantity or quality. Their contention was that only on one occasion—in June, 1914—was there a well-defined burn caused by smoke, yet the effects of this gas current quickly disappeared, and no permanent damage was done to the crops nor claimed by the farmers.

Practical Experiments on Nearby Farm

As mentioned above, the United States Smelting Co. had maintained an investigating staff on smoke problems, as well as utilizing the services of independent experts since 1908. In 1914 is acquired a run-down 180-acre farm, one mile from its stack in the direction of the prevailing wind, a farm which had been worked almost continuously since the Mormon settlement without regard to crop rotation or adequate fertilization. Prof. E. W. Ledyard was given charge of this venture, and by proper care, fertilization and drainage he was able to grow successfully over 100 different crop varieties. His studies of the actual SO_2 concentrations led him to the extreme of making determinations at various stations at five-minute intervals for 100 hours. His studies of drainage conditions and ground water were very minute, and led him to maintain that much if not a great majority of the plant bleaching ascribed to smelter smoke was due to improper irrigation or drainage.

Within the last several years the American Smelting & Refining Co. has acted upon the findings of its smoke investigators, headed by Dr. P. J. O'Gara. These conclusions were briefly described in METALLURGICAL & CHEMICAL ENGINEERING, vol. 17, p. 682 (Dec. 15, 1917). Dr. O'Gara and certain members of his staff by means of experimentation briefly indicated in the article quoted, and illustrated in Figs. 1 and 2, established the standards of plant injury as determined by weather factors and varying concentration of SO_2, and whenever what appeared to them to be actual SO_2 injury occurred they were ready to recommend proper compensation. The logical consequences of these findings involved the construction of a number of improvements at the Murray plant such as the installation of a 455-ft. stack with flues so arranged that it will discharge the smoke from the boiler houses as well as from the roasting depart-

ments. In case the heat derived from this source is not sufficient to insure proper diffusion of sulphur dioxide, an auxiliary coal furnace has been installed at the base of the stack. In conjunction with this device the company has also completed a very fine and efficient Cottrell plant, designed and constructed by its engineer, J. B. McIntosh.

In the decree just issued Judge Johnson notes that conditions at the present time are much better than they were in 1908, but still there was much to be desired in 1916, when the suit was started. He finds that

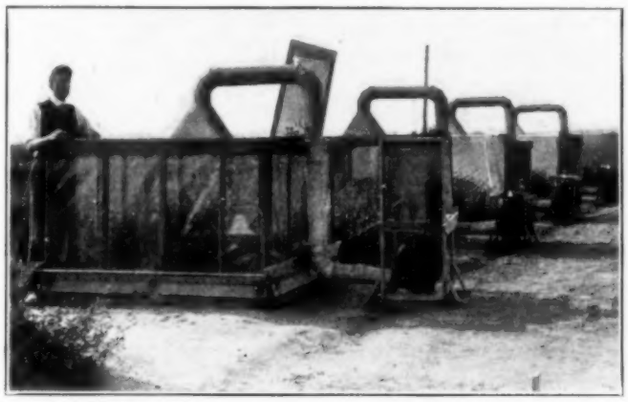


FIG. 2. BATTERY OF CABINETS IN ACTION AT THE A. S. & R. FARM

The cabinets shown are set over the plots when it is desired to fumigate the plants. The light wood frames are covered with thin sheet celluloid, which gives a high light factor. The blower is connected with slip joint to the cabinet delivery pipe, and the volume of air measured by Pitot tube. The SO_2 is measured by a capillary meter shown in the frame above the blower. The temperature and humidity of the air in the cabinets remain essentially the same as the outside air, because of the large volume of air passed through the cabinets. Each blower has a capacity of 10,000,000 c.c. per minute. The cabinets are 6 x 6 x 4 ft. high. In all series of experiments use was made of check cabinets through which air, unmixed with SO_2, was passed. This was for the purpose of checking the light factor.

smoke damage by sulphur dioxide has occurred at many times and many places in Salt Lake Valley in recent years. He also finds that the smelting plants have not at all times been able to control or dilute the sulphur dioxide so as to avoid damage to nearby vegetation. The American Smelting & Refining Co., by its so-called "sea-captain" methods of operation pending completion of the high stack and electrical precipitator, has much more nearly approached perfection—in fact, the Court was able to find no specific case of smoke injury in the Murray zone during the 1916 season. In this system the management recognizes certain optimum conditions of light, temperature, humidity and wind direction, which, when occurring, are bound to cause smoke injury if more than a certain quantity of sulphur is being evolved at that time. By keeping the weather eye out, therefore, the company is enabled to close down certain smelting units (roasters) so as to reduce the actual amount of sulphur evolved during these dangerous times.

Under all of these circumstances the Judge allows operation to continue temporarily, provided that sulphur trioxide or sulphuric acid is neutralized, precipitated or removed to such an extent that "no injurious amount" exists in the gases eventually discharged. All solid products except unconsumed carbon are removed as far as practicable by modern baghouse plants or Cottrell installations, and the resulting fume is resmelted under the same precautions as to smoke and fume which is given the ordinary ore mixture. Sulphur dioxide in the smelter gases at the United States Smelting Co. may not exceed a maximum of 0.75 per cent by volume. On the other hand, the sulphur dioxide analysis on the areas surrounding the American Smelting & Refining Co.'s plant may not exceed an hourly average of one part per million in the growing season of the year, while during the non-growing seasons three parts per million may not be exceeded.

The complaining farmers were awarded $20,000 in costs. The companies are also to bear the expense of a commissioner and his staff appointed by the court to observe smelting operations, to make necessary tests and to propose remedies for smoke nuisances, and to examine complaints, having, together with the smelting companies' agents, full freedom of action and information from both parties to any controversy. Prof. R. E. Swain of Leland Stanford University was appointed commissioner and will make his report to the Judge on Feb. 1, 1921. If Prof. Swain reports and the Court decrees that the methods employed by the American Smelting & Refining Co. will in all probability obviate smoke damage, then the United States Smelting Co. is obligated to take like steps immediately.

Having given the foregoing historical background, some extracts from Judge Johnson's decision will be of interest to those who have been engaged in investigating or fighting smoke damage.

In the case under discussion, the complainants say that sulphur dioxide and sulphur trioxide escape from the smelters and are offensive to the inhabitants, deteriorate wire screens, fencing and metal work, and

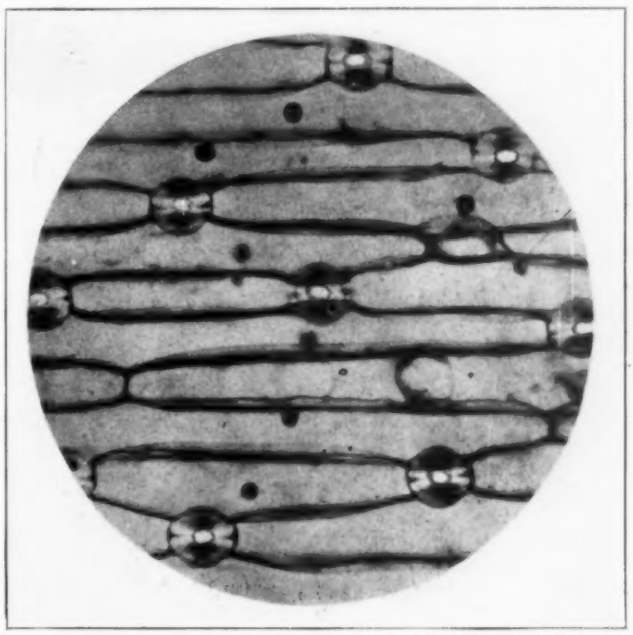


FIG. 3

Stomata or breathing pores of plant leaf, showing open appearance. It is through these small apertures that gases pass into the leaf. While 100 to 300 stomata may be present on 1 sq.mm. of leaf surface, there are a few cases where there may be as many as 700. Very young leaves with immature stomata are more resistant to SO_2 and other gases than mature leaves. (O'Gara. × 175.)

destroy fruit and ornamental trees. Such gases, in connection with arsenic, antimony and zinc compounds, poison crops so that they cannot be used.

On the other hand, the smelting companies contend that no arsenic or sulphur trioxide escapes except when the bags in their baghouses are being shaken, which happens once a day. The amount of noxious fumes

liberated at that time is so small as to be entirely negligible. On the other hand, sulphur dioxide is so diluted by nitrogen and air as to be harmless to animal or vegetable life, and in such quantities is incapable of causing deterioration of metal work.

The Judge finds that practically all sulphur dioxide goes out of the smelters through their main chimneys, except a little "ground gas." In both plants a very efficient smoke-collecting system, flue and baghouse have been installed, which collectively remove all solids from the gas. Sulphur trioxide is sufficiently neutralized by calcium oxide or zinc oxide intentionally introduced into the flues, and thus is converted into solids. Consequently, any damage that is done at the present time is, by exclusion, due to sulphur dioxide.

The evidence shows sharp controversies over the causes of observed plant injury, but a great portion of the evidence was merely a matter of opinion and was of a relative value, being highly influenced by the preconceptions and point of view of the witness. Thus, the plaintiffs and their witnesses were all farmers who were untrained observers and prone to call damage of all sorts "smoke damage," reasoning from conditions which they had observed prior to 1908. They would therefore testify that smoke was responsible even when plant damage was clearly due to other causes. Even the expert witnesses employed by the farmers mistakenly held that leaf injury which looked like sulphur dioxide injury was actually caused by SO_2.

On the other hand, the smelting companies' witnesses were unconsciously biased on the other side—even the farmers who testified for them. The smelting companies' experts often found other sufficient causes than sulphur dioxide to account for all mischief in the smoke zone. However, the testimony of the smelter experts as to fact is far more valuable than other testimony merely founded on opinion.

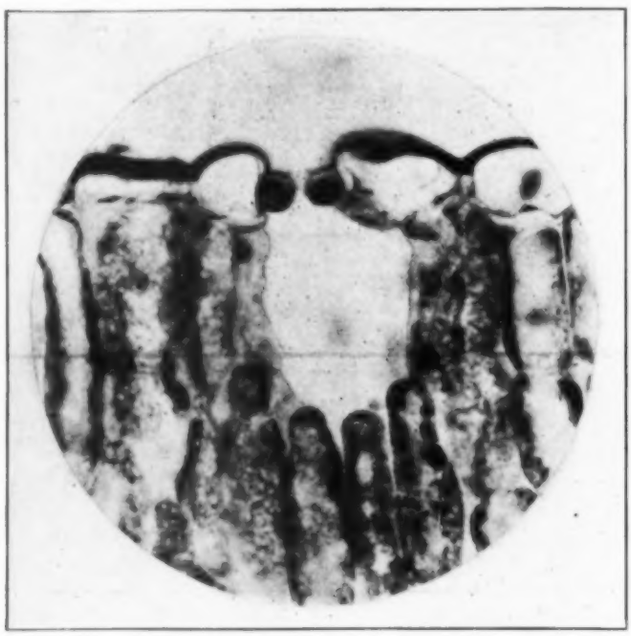


FIG. 4

Cross-section through single stoma or breathing pore of alfalfa leaf. The two guard cells, the sub-stomatic chamber and the palisade cells below and surrounding the chamber are shown. Gases passing through the stoma and into the chamber come into contact with the thin cell walls, and readily diffuse through them into the cells. In this way CO_2 enters the leaf cells and through the agency of light combines with the cell water, sugar being one of the first recognizable products. (O'Gara. × 175.)

The research work of these scientific men has been admirable, and it is unfortunate that the plaintiffs and other farmers of the community have not taken more interest in the experimental farms of the defendants and profited by the information acquired in the operation of said farms and the experiments made at these stations.

Another point in the opinion handed down by the Judge is especially worthy of note and consideration. He says that the experts employed by the American Smelting & Refining Co. have been able to make some settlements with the complaining farmers. Their scientific investigations were of the highest class and their officials were of an open mind. Consequently the settlements which had been made by them tended to establish standards of appearances, circumstances and conditions which evidence injury by sulphur dioxide.

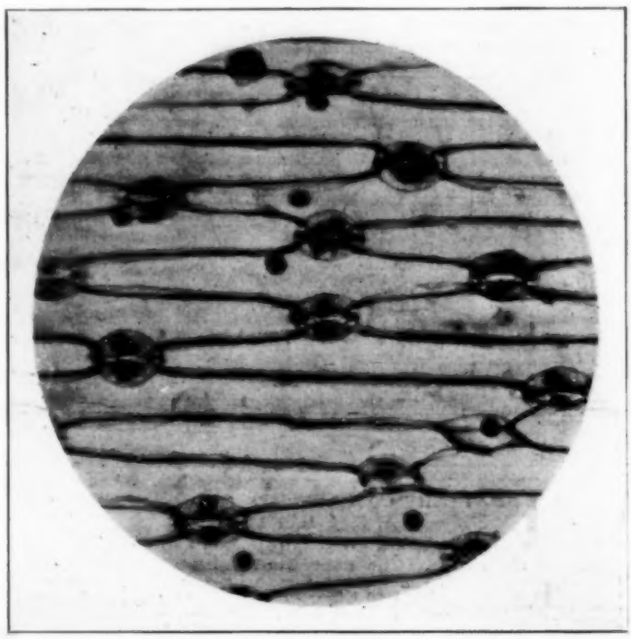


FIG. 5

Stomata or breathing pores of plant leaf, showing closed appearance. In many plants closure takes place in the absence of light, but temperature and relative humidity of the asmosphere are also important factors which govern stomatal movements. The effect of rain drops on foliage is to close the stomata. (O'Gara. × 175.)

Discussing the accepted fact of plant injury by sulphur dioxide, the Judge notes that it is immaterial whether SO_2 is oxidized to SO_3 in the ground, in the air or in the plant tissue itself. The main fact is that under such conditions it actually causes harm to plant life if in sufficient concentration.

He throws out of court, however, analyses showing the sulphur contents of the ground, the plants growing on the ground and momentary quantities in the air. All of these data he feels are too meager for much weight, and sulphur contents in plants might not affect their vitality or their proper use.

> Such a condition evidences a departure from the usual and, perhaps, natural, but the power of adjustment of life to environment is too great to base upon such departure alone the conclusion that it produces a deterioration in the vitality of the plant, or the quality or quantity of yield.
>
> The evidence respecting the effect of the presence of SO_2 or possibly SO_3 in the atmosphere upon wire screening and fencing creates a suspicion that deterioration results, but the evidence is not of that convincing character that I feel would justify a finding in the case to that effect.
>
> The evidence is insufficient to show that the presence

of SO_2 in the atmosphere causes injury to vegetation and plant life, where there is not external evidence of injury appearing in the plant. In other words, the evidence is insufficient to show any invisible injury to vegetation or plant life occasioned by SO_2 acting either through the soil or the atmosphere.

One part of sulphur dioxide to one million parts of air under certain favorable conditions will mark, dry up or bleach foliage of certain non-resistant crops. The skin or bark of growing plants is much more resistant, while young fruit, blossoms, and grain, while it is heading out, are less resistant than the bark, but more resistant than foliage. The effect seems to be that sulphur dioxide passes from the air to the leaf structure through stomata, destroying cell life and drying up the structure in a way which is visibly evident.

Factors Modifying Smoke Damage

"The appearance of SO_2 injury in the foliage of plants and its extent depend upon certain conditions," quoting verbatim the words of Judge Johnson's decision.

"1. The sensitiveness of the plant to SO_2 injury.

"2. The concentration of SO_2 in the atmosphere.

"3. The length of time during which the plant is subjected to SO_2.

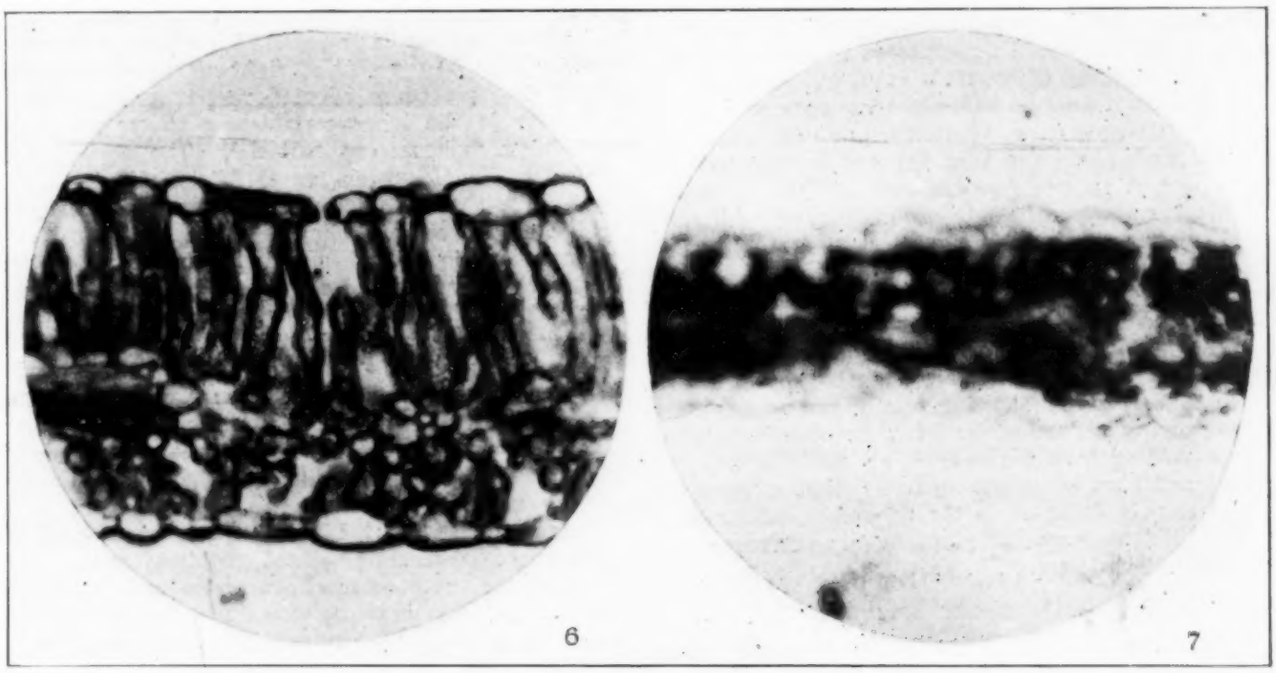
"4. The humidity of the atmosphere.

"5. The presence or absence of those conditions which affect or control the opening or closing of the stomata, as light, darkness, heat and cold.

"As a rule SO_2 seems to attack the leaves and foliage at their points and edges, extending into the leaf in proportion to the severity of the injury. The effect of SO_2 injury—that is to say, the markings of the foliage—is observable practically at once. The appearance of the markings of the leaf tends to change somewhat with the lapse of time. The discoloration of the leaves or the appearance of the markings on the leaves resulting from SO_2 injury is not the same in all plants and is not distinguishable from discoloration and markings resulting from many other causes, whether examined by the eye alone or under a microscope, and so far as the evidence discloses there are no structural or chemical characteristics of SO_2 injury which distinguish it from injury by many other causes. Injury caused by frost, sunburn, sun-scald and alkali are among the causes producing leaf injury in every characteristic similar to that caused by SO_2—that is, relatively sudden deterioration, disintegration, and breaking down of the internal cell tissues of the leaf.

"Leaf injury occasioned by insects directly attacking the leaf of the plant is ordinarily readily distinguishable from SO_2 injury. . . .

"Fungous diseases of plants, in many cases, cause leaf deterioration identical with SO_2 injury. These bacterial diseases have each their several characteristics other than leaf deterioration common to them all and to SO_2 injury, and the presence of the characteristics of disease will ordinarily classify the leaf injury as injury resulting from disease and not from the presence of SO_2. . . .



FIGS. 6 AND 7. NORMAL AND INJURED ALFALFA. (O'GARA. × 180.)

Fig. 6 shows cross-section of normal alfalfa leaf with the characteristic cellular appearance or structure. Two stomata, one closed, the other open, are shown in the upper portion of the leaf. The long cells in the upper half are known as palisade cells. Contrast the appearance of the normal structure with that of the injured leaf, Fig. 7, which shows no structure. It is plainly seen that the injured leaf has shrunk to less than one-half its original thickness, as compared with the normal leaf. Fig. 7 shows cross-section of alfalfa leaf after acute SO_2 injury. The cellular structure, as shown in the normal leaf, has practically disappeared. Leaf injury by other gases, fire, frost, drouth and other causes presents the same appearance. There is no distinguishing microscopic picture which will separate one from the other. In all cases the part of the leaf which is injured collapses because the cell water escapes from the injured cells.

Sulphurous Injury Indistinguishable

"It will be observed that each one of the causes of leaf markings producing injuries identical with and indistinguishable from leaf markings produced by SO_2 has its own peculiar and accompanying factors. For instance, frost is accompanied by a temperature below 32 deg. F., and ordinarily its effect is observed over a relatively large area of country. Sun-scald is accompanied by hot sunshine preceded by irrigation or rain. Sunburn is accompanied by hot weather and lack of

moisture. Alkali injury shows on crops in soils containing alkali. Similarly, SO_2 has its accompanying factors—namely, injury from SO_2 always occurs in the path of the wind blowing over and from smelting plant or the stacks from which sulphur dioxide is discharged. . . .

"The lapse of time following an opportunity for injury in any given case is of no aid in distinguishing the cause of the trouble, since under like conditions recovery from the effect of leaf injury caused by sunscald or sunburn, and in some cases alkali, is equally rapid as recovery from injury occasioned by SO_2. . . . It should be noted, however, that in many cases alkali injury persists and is progressive, so that it often happens that a growing crop may show the effect of alkali at first by relatively few and insignificant markings, but these markings, as time elapses, constantly increase in number and extent and persist throughout the growing season.

"The distinguishing factor of SO_2 injury, as already observed, is that it occurs in the path of the wind passing over the smelter. I do not mean to say that it may not occur at times of apparent calm, but in respect to that I think it may be assumed that there is no such thing as absolute calm, or even a practical calm, that extends over any large area for any great length of time. . . .

"Another feature of SO_2 injury distinguishing it from similar markings by other causes is a path or zone of markings showing the course and direction of the gas and which, as above noted, is always in the direction of the wind from the smelter at the time. This path or zone is fan-shaped, increasing in width from the smelter. . . . Yet there are instances shown by evidence of SO_2 injury showing locally and without the accompanying characteristic of a fan-shaped path or zone extending from the smelter, at least observed and traced, and I am led to the conclusion that at times the gas stream is deflected to the ground at points more or less distant from the plant by air currents, with resulting SO_2 injuries. . . .

Economic Loss

"There can be little doubt that SO_2 injury, when occurring at a critical period in plant development, results in economic loss—that is, substantial diminution of crop yield. The tendency of growing crops is to throw off or overcome the injury inflicted by SO_2, or injury caused by any other agent, and the observations of witnesses upon the matter are that markings caused by SO_2 will cease to be noticeable, during the season of rapid growth and development, within a short time, the length of time in any case depending upon the species of the plant affected, the time of year and, generally, upon every factor that promotes or retards plant growth and development.

"The tests made at the experimental farm of the A. S. & R. Co. tend to minimize the economic loss caused by SO_2 injury. There are many factors to be taken into consideration in determining the question of economic loss by SO_2 injury in any particular case.

"Under all the evidence in the case, I am led to the conclusion that SO_2 injury occurring at a critical period in plant developments results in appreciable economic loss. Or, stated another way, SO_2 injury, occurring at a time or under conditions unfavorable to plant development and crop yield, causes more or less economic loss."

Use of Liquid Oxygen as an Explosive

Liquid oxygen as an explosive was first used by the Germans in a coal mine in 1897, following Linde's invention of his liquefying apparatus in 1895. Trials made in the Simplon tunnel are said to have been favorable.

In 1900 Claude of France patented the rectification principle. Linde in 1902 designed his rectification apparatus. Both types of apparatus are extensively employed in liquefying gases. In 1904 Dewar of Great Britain invented the Dewar flask—a container for liquefied gases.

It remained for the war to bring out further developments, and its use was widely extended in Germany during this period. The Allied countries, being able to import nitrates from Chile, did not take up its use, but if the war had continued the United States would probably have been compelled to do so. The use of this explosive commercially will now depend upon its own merits.

Experiments of the Bureau of Mines have shown that a liquid oxygen can be prepared with a blasting strength greater than 40 per cent straight nitroglycerine dynamite. The procedure adopted was to place a No. 6 detonator in the inner cartridge, a cheese-cloth sack containing carbonaceous material. The cartridge is soaked in liquid oxygen ten to fifteen minutes in an improved container devised by the Bureau. The cartridge, frozen stiff, is slipped into a pasteboard container, placed in the hole, a wad of cotton placed on it, a brass tube inserted, and clay tamped around the tube. The hole left by the tube provides an outlet for evaporating oxygen until the shot is fired.

Advantages of this explosive compared with dynamite and black blasting powder are lower cost per ton of material blasted, elimination of dangers in transportation from premature ignition, misfires or unexploded sticks in blast hole, in handling and thawing, or in storage magazines.

Disadvantages are: Liquid oxygen, because of its rapid evaporation, must be used quickly after charging, this limiting the number of shots; the maintenance of a liquefying plant near the mines, and the fact that the explosive cannot be used in gaseous coal mines.

This method offers great possibilities for lessening blasting costs in non-gaseous coal mines, and in metal and mineral mines using a chamber method when only a few shots are fired at one time. The chief cost is that of the oxygen. It is thought that this can be decreased through promised improvements in liquefying machines.

Shipments of Sulphur From Sicily

The export of sulphur from Sicily during 1919 amounted to 147,286 tons, as compared with 231,390 tons in 1918. Of this amount approximately 45 per cent was exported to France, the remainder being shipped to Greece, Turkey, Spain, England and South America. There were no sulphur exports to the United States from Sicily during 1919. The estimated amount of stocks on hand on Dec. 31, 1919, amounted to 136,991 tons.

The production slightly improved in 1919 as compared with the immediately preceding years, but is still far below the pre-war figures. Industrial troubles and fires largely contributed toward curtailing the output last year. The outlook for 1920 is not considered very bright on account of the many industrial, transport and exchange difficulties to be contended with.

Pressure and Temperature Relations for Vapor of Liquids

Derivation of Formulæ Giving the Relations of Vapor Pressures—Boiling Pressure Ratios to the Absolute Temperature—Absolute Boiling Point Ratios From Known Physical Constants—Latent Heat of Evaporation, Molecular Weight and Absolute Boiling Point

By P. B. WILLIAMSON

RECENTLY while working out the design of a cracking process for producing gasoline, it was necessary to have, among several other things, some quantitative idea of the change under different pressures of the boiling points of quite a large number of hydrocarbons—especially of the paraffines. On consulting a number of authorities it was found that very little had been published on the vapor-tension phenomena of those compounds and furthermore that substantially nothing had been done toward determining a general expression involving the pressure on a liquid and the latter's boiling point under that pressure—or, in physicochemical terms, the general relation between the temperature of a liquid and its corresponding vapor tension. A search for information on the subject, including, as it did, correspondence with some of the leading physical chemists and research institutions of America, forcibly brought to mind a statement written by the author several years ago in his physics lecture notes: "No definite law is known (1910) connecting the boiling point of a liquid with the pressure; all we can say in general is that the greater the pressure, the higher the boiling point." It is apparent, however, that if such a law does exist, its application would be extremely valuable: First as a check on experimental work on the vapor-tension variation of liquids; secondly, as a check on the normal boiling point, melting point and density of liquids; and thirdly, for practical determination of the vapor-tension behavior of liquids on which no vapor-tension data have yet been published.

Bertrand's Empirical Formula

In reviewing the literature it was found that Bertrand had investigated twenty-two liquids and found the following equation to be applicable to them:

$$P = G\left(\frac{T_p - \lambda}{T_p}\right)^g \qquad (1)$$

where

g = 50 for twenty-one of the compounds and 20 for chloroform.

P = pressure in mm. of mercury.

T_p = 274 + pressure boiling point in deg. C.

G,λ = constants peculiar to each liquid.

The use of this formula entails the determination for each liquid of three constants, g, G and λ. In order to simplify the expression the first step made was to modify (1) so as to give the pressure in atmospheres, to do which the following analysis rapidly ensued:

$$P \div p = \text{a constant, } c \qquad (2)$$

where p = pressure in atmospheres, 760 mm.

Then from (1) for p_n = normal pressure, 1 atmosphere

$$c = P_n = G\left(\frac{T_b - \lambda}{T_b}\right)^g \qquad (3)$$

where T_b = normal b.p. (abs.) of the liquid.

Substituting (3) in (2) and then multiplying through by p gives

$$P = pG\left(\frac{T_b - \lambda}{T_b}\right)^g \qquad (4)$$

Whence, from equating the identities (1) and (4) and solving for T_p, we get

$$T_p = \frac{\lambda}{1 - \frac{T_b - \lambda}{T_b}\sqrt[g]{p}} \qquad (5)$$

from which the constant G has thus been eliminated.

Bertrand reckoned from an absolute zero of —274 deg. and obtained the values of λ enumerated in the table given in sec. 5, p. 520, vol. 1, of Castell-Evans' "Physico-Chemical Tables" (Griffin, London, 1902-11). For an absolute zero of —273.1 deg. those values must be modified accordingly.

Vapor Tension Constant Expressions

Having derived equation (5) it was decided to determine whether there exists a definite relation for each compound between its "vapor-tension constant," λ, and certain of its properties, such as melting points, boiling points, densities and molecular weights.

It is hardly necessary to state that considerable disagreement arises in several instances as to the value assigned to the various properties, such as, for example, the melting point of CO_2, the boiling points of H_2S, C_2H_5Cl, etc., and on various densities. Naturally the densities must be reduced to some standard; which was taken as 273.1 deg. abs.

Omitting quite a lot of detail, it would appear that λ is given by an equation, say, of the form

$$\lambda = \alpha T_b^{\beta} T_m^{\gamma} d^{\delta} (\log W)^{\eta} \qquad (6)$$

in which the coefficient α and the exponents β, γ, δ and η are probably universal constants. The most probable values of these constants may be found from a large number of liquids (using the most positive values of their properties) by solving by the method of least squares the following equation:

$$\log \lambda = \log \alpha + \beta \log T_b + \gamma \log T_m + \delta \log d + \eta \log \log W \qquad (7)$$

Not having good facilities for the immense amount of calculation the above method involves, nor the opportunity of determining the correct data needed therefor, no attempt has been made to derive the above constants precisely. It will be shown, however, that a general formula for λ can be found involving only the

comparatively well-known constants of the specified liquid—if not of the form just suggested, yet of some other type of algebraic expression.

According to Bertrand, in his equation (1), for chloroform $g = 20$ and $\lambda = 120$. But using equation (5), for chloroform $g = 50$, as with the other liquids investigated by Bertrand, and $\lambda = 61.6$, which agrees with (6) within the limits of error of the data used. Furthermore, approximate calculations on a large number of compounds picked out at random from the vapor-tension tables in Castell-Evans, pp. 451-523 (vol. 1), considering the limits of error established by the agreement of the authorities quoted therein, make it appear that Bertrand's constant $g = 50$ is probably universal.

The constant λ may be experimentally determined for liquids having no published vapor-tension tables. Thus, rearranging (5) and putting $g = 50$, we get

$$\lambda = \frac{T_p T_b (\overset{\text{as}}{V}\, p - 1)}{T_p \overset{\text{as}}{V}\, p - T_b} \qquad (8)$$

When the pressure is normal ($p = 1$ atmosphere), then $T_p = T_b$, and those values substituted in (8) give $\lambda = 0 \div 0$ (indeterminate). Neither by rearrangement nor by successive differentiation of the numerator and denominator of the right-hand side of (8) can the indeterminate form be got rid of. That fact can be proved mathematically, but the proof is too long for inclusion here; and, anyhow, it is apparent that any reduction of (8) to normal pressure will give the constant λ in terms of the normal boiling point T_b. That λ does not depend upon T_b alone readily shows from even a casual inspection of the table. However, by finding a number of boiling points for different pressures (other than normal) a mean value of λ follows from (8).

Degree of Precision of Application of λ

Remarking further on positiveness of tables: Probably the most reliable vapor-tension table given in Castell-Evans is that for water, on p. 461 (vol. 1). Substituting pairs of corresponding values from that table in equation (8) shows that the different values of λ thus obtained do not coincide. Thus, for example,

p	T_p	λ
10	453.41	78.41
50	537.67	78.35
170	625.1	78.94

Since the values of λ thus calculated do not vary uniformly with the pressure p (as they should do, were there any theoretical variation), but, rather, "oscillate," it follows that the thermometry of the table is not exact. In the same manner and, it is reasonable to suppose, on the same account the values of λ calculated from the tables for other liquids vary according to the positiveness of the thermometry involved.

Bertrand's value for water of λ, referring to absolute zero as —274 deg., is 78.3. That value referred to an absolute zero of —273.1 deg. becomes 78.112. By striking a mean among the values calculated back from the table for water by (8), we get $\lambda = 78.5$. The same order of difference applies to λ for those of the other liquids checked. It would appear, then, that Bertrand's values need revision. For engineering calculations, however, all of the variations mentioned so far may be overlooked.

In conclusion, referring to equation (19) it follows the following relation should hold:

$$\lambda = 0.0081 W L_b \qquad (19a)$$

More or less empirical methods have been tried above, deriving expressions involving a constant to be found for each liquid either by experiment or by possibly evolving a general equation for the constant itself. As the first determination, for authoritative purposes, would require considerable laboratory work and the second determination might entail no less and probably much more labor for the theoretical chemist, it seemed desirable to approach the subject from another angle, with the rather astonishing results below.

BERTRAND'S λ TABLE

Substance	Formula	λ	T_m	T_b	W	Log W	d
Carbon dioxide	CO_2	35	195	217	44	1.6435	1
Hydrogen sulphide	H_2S	37.1	188	212	34.1	1.5326	0.88
Ammonia	NH_3	46.7	195	235	17	1.2313	0.623
Cyanogen	(CN)	47.3	239	252	26	1.4151	0.88
	$(CN)_2$				52	1.7162	
Boron trichloride	BCl_3	48.8		291	117.4	2.0696	1.434
Sulphur dioxide	SO_2	49.5	197	263	64.1	1.8067	1.434
Ethyl chloride	C_2H_5Cl	50.5	132	293	64.5	1.8096	0.921
Cyanogen chloride	(CN)Cl	53.1	255	289	61.5	1.7887	1
Carbon disulphide	CS_2	54.8	163	319	76.1	1.8816	1.292
Ethyl bromide	C_2H_5Br	55	157	312	109	2.0373	1.45
Ethyl ether	$C_2H_5OC_2H_5$	55.4	156	308	74.1	1.87	0.73
Silicon tetrachloride	$SiCl_4$	57.9	184	332	170.1	2.2308	1.524
Ethyl iodide	$CH_3.CH_2I$	60.6	165	345	156	2.193	1.96
Phosphorus trichloride	PCl_3	61.6	161	349	137.4	2.1381	1.613
Chloroform	$CHCl_3$	61.6	210	335	119.4	2.077	1.526
Carbon tetrachloride	CCl_4	61.7	248	350	153.8	2.1871	1.6
Methyl alcohol	CH_3OH	71.5	179	340	32	1.5056	0.81
Ethylene bromide	$CH_2Br.CH_2Br$	72.9	283	405	187.9	2.2739	2.1
Ethyl alcohol	C_2H_5OH	76	161	351	46.1	1.6632	0.81
Pinene	$C_{10}H_{16}$	76.8	....	429	136.1	2.134	0.89
Water	H_2O	78.3	273	373	18	1.2557	1
Acetic acid	$CH_3.COOH$	78.6	290	391	60	1.7784	1.03
Sulphur	S	135	390	717	32.1	1.5061	2
	S_2	.....	...	...	64.1	1.8071	.....

Differential Relations

Consider the unsaturated vapor of a pure liquid: From the standpoint of differential relations, it seemed possible that a general solution might ensue from the familiar linear equation always coming up when dealing with "single-energy" effects, viz.:

$$\frac{dT}{dp} + X_1 T = X_2 \qquad (9)$$

where X_1 and X_2 may or may not involve p.

The standard solution of (9) is

$$T = e^{-\int X_1 dp} \cdot \left(\int X_2 e^{\int X_1 dp} \cdot dp + C\right) \qquad (10)$$

where e is the Napierian base and C is an integration constant dependent upon the terminal conditions of the problem.

From the nature of the problem the standard solution (10) calls for any of three combinations, viz.; X_1 and X_2 both involve p; X_1 is a constant and X_2 involves p, and X_1 involves p and X_2 is a constant. The simplest choice is the last. Now the curve plotted between absolute temperatures as ordinates and corresponding pressures as abscissæ theoretically is parallel to the axis of abscissæ when the pressure is infinite; *i.e.*, when $p = \infty$ then $dT \div dp = 0$ and $X_1 T = X_2$. But if X_1 involves p in a certain way then $0 = X_2$ when $p = \infty$, or by the third assumption X_2 is constantly zero; which reduces (10) to

$$T = Ce^{-\int f(p) \cdot dp} \qquad (11)$$

Since the temperature of the liquid has only a theoretical value when the vapor pressure of the liquid is zero, consideration of the terminal conditions as those when p is zero takes us rather too much into the abstract. It is more convenient to consider the integration-constant reference conditions as those under the

normal pressure of one atmosphere; thus obtaining from[1]

$$T_p = T_b\, e^{\tau(p^\zeta - 1)} \qquad (12)$$

where

T_p = temperature of the liquid (absolute C.)
T_b = normal boiling point (abs.) of the liquid
T_p = vapor tension of the liquid in atmospheres
τ, ζ = constants peculiar to each liquid.

Upon applying (12) to over 125 liquids for which the writer had to hand vapor-tension tables, it was found that while $\zeta = \frac{1}{9}$ (approx.)[1] for all of those liquids, on the other hand, τ varied from $\tau = 0.567$ for arsenic trioxide to $\tau = 2.17$ for liquid helium, with an average around 0.8.

Solution of the Vapor Tension Constant Tau

The difficulty with indeterminate forms is met with upon attempting to evaluate τ from (12). But, taking another tack (cf., e.g., "The Principles of Physical Chemistry," by E. W. Washburn, 1st ed., 1915, McGraw-Hill, N. Y., Chap. XII., esp. secs. 1, 2, etc.) this obstacle may be avoided by the use of the well-known expression

$$\left(\frac{\delta p}{\delta T}\right)_{p_1,\, x} = \frac{L_v}{v_v T} \qquad (13)$$

where

L_v = molal heat of vaporization of the liquid
v_v = molal volume of the liquid in the vapor state under conditions p_1, x.

For a theoretically perfect vapor (13) is integrated by

$$\ln \frac{p_1}{p_2} = \frac{L_v}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \qquad (14)$$

in which

ln = natural logarithm
R = the universal gas constant dependent only upon the units employed.

Now if we put $p_1 = p$, $p_2 = 1$ atmosphere, $T_1 = T_b$, and $T_1 = T_p$ in (14), then

$$\ln p = \frac{L_v}{R}\left(\frac{1}{T_b} - \frac{1}{T_p}\right) \qquad (15)$$

But L_v varies with the temperature in the same manner but in different degree for each liquid and, therefore, introduces the necessity for its positive determination accordingly—as a general rule quite a task within itself. But by considering differential increments Δp and ΔT as added, respectively, to the normal pressure and boiling point, it may be written

$$\left.\begin{aligned} p = 1 \quad + \Delta p &= p_\delta \\ T_p = T_b + \Delta T &= T_\delta \\ L_v = L_{vb} & \end{aligned}\right\} \qquad (16)$$

But $$L_{vb} = WL_b \qquad (17)$$

where

L_b = latent heat of vaporization (say, in calories per gram) at the normal boiling point of the liquid.
W = molecular weight of the liquid.

The last assumptions, then, transform (15) into

$$\ln p_\delta = \frac{WL_b}{R}\left(\frac{1}{T_b} - \frac{1}{T_\delta}\right) \qquad (18)$$

which rearranged gives

$$T_\delta = 1 \div \left(\frac{1}{T_b} - \frac{R}{WL_b} \cdot \ln p_\delta\right) \qquad (19)$$

Now from (12)

$$\tau = \frac{\ln (T_p \div T_b)}{p^\zeta - 1} \qquad (20)$$

Substituting (19) in (20) gives

$$\tau = \frac{-1}{p^\zeta - 1} \cdot \ln\left(1 - \frac{RT_b}{WL_b} \cdot ln\ p_\delta\right) \qquad (21)$$

The smaller the value assigned to Δp, the more accurate is the relation (21) and, at the same time, the closer to an infinitesimal[2] is $\ln p_\delta$. Hence, taking advantage of the expansion

$$\ln(1 - x) = -x - \tfrac{1}{2}x^2 - \tfrac{1}{3}x^3 - \tfrac{1}{4}x^4 - \ldots\ldots \qquad (22)$$

the terms beyond the first on the right-hand side may be disregarded and thus enable us to reduce (21) to

$$\tau = R_1 \frac{T_b}{WL_b} \qquad (23)$$

where R_1 involves R and ζ, which are practically the same for all the liquids investigated. Checking (23) against water, mercury, ether, etc. (in fact, against over fifty liquids, and solids and gases in the liquid state), gives the almost exactly general value $R_1 = 17.42$ (slide rule); that is,

$$\tau = 17.42 \frac{T_b}{WL_b} \qquad (24)$$

an expression involving only the comparatively better known constants of a liquid—the normal boiling point, the molecular weight, and the latent heat of vaporization (at normal b.p.) of the liquid.

A General Vapor Tension Temperature Law

The foregoing analysis gives a basis for the statement that: The temperature of a liquid varies with changing vapor tension according to the logarithmic law; the natural logarithm of any particular temperature (absolute) being equal to a known function of the vapor pressure, plus the natural logarithm of the normal boiling point, or, algebraically

$$T_p = \text{illn}\left[17.42 \frac{T_p}{WL_b}(\sqrt[\zeta]{p} - 1) + \ln T_b\right] \qquad (25)$$

or, using common logarithms,

$$T_p = \text{illog}\left[7.56 \frac{T_p}{WL_b}(\sqrt[\zeta]{p} - 1) + \log T_b\right] \qquad (26)$$

By rearranging (26) an expression for vapor pressure (atmos.) is obtained (27)

$$p = \left[1 + 0.1325 \frac{WL_b}{T_b}(\log T_p - \log T_b)\right]^\zeta \qquad (27)$$

and for latent heat (calories per gram at normal b.p.) in (28)

$$L_b = 0.1325 \frac{W}{T_b}(\log T_p - \log T_b)(\sqrt[\zeta]{p} - 1)^{-1} \qquad (28)$$

Since the pressure on a liquid is equal in magnitude to the vapor tension (pressure) of the liquid when boiling under that pressure, equation (26)—or (25), or

[1] Thus corresponding to the linear equation $\frac{dT}{dp} - \frac{\tau}{9} p^{-\frac{8}{9}} T = 0$

[2] Of a higher order than $p^\zeta - 1$.

(12) with (24)—arrives at an answer to the question often asked in practice:

"What will be the boiling point of so-and-so when the pressure on it is increased or decreased to such-and-such a value above or below normal?"

Cracking-process engineers, among others, will quickly recognize the query. In applying (26) to petroleum, however, Dalton's Law of Partial Pressures must be considered. In fact, the application to any mixture, whether a constant-boiling one or a fractional-distillation one, supplies enough material for another paper on the subject.

Equation (27), inversely, arrives at conclusions regarding pressures—coming up, say, in superheating problems, etc.

Equation (28) might lead to another method for checking the latent heat of vaporization at the normal boiling point. By experimenting upon a substance whose latent heat determination presents especial difficulty by former methods, a table of temperatures and corresponding pressures may be developed (for the sake of obtaining a mean), and therefrom the value of L_b computed by (20).

Going further, if a substance should present itself and its latent heat and a table similar to that just mentioned can be found, then the molecular weight of the substance directly follows from (28) as

$$W = 7.56 T_b L_b (\sqrt[7]{p} - 1)(\log T_p - \log T_b)^{-1} \quad (29)$$

From Berthelot's equation (cf. Washburn, *loc. cit.*, Chap. II, p. 36, etc.)

$$W = DRT_b \left[1 + \frac{9T_c(T_b^2) - (6T_c^2)}{128 p_c T_b^3} \right] \quad (30)$$

where

D = density of vapor at normal b.p.
T_c = critical temperature (abs.)
p_c = critical pressure (in atmospheres)
R = the gas constant (dependent upon density unit employed).

From (30) there may be obtained an equation for T_c, the critical temperature, or for p_c, the critical pressure, which in connection with (26) or (27) gives a check on either of those properties of a substance. The equations are rather involved—yet worse things could be encountered. It is hardly necessary to state that any property sought in one of the above ways should depend only upon data from other sources, and not upon values previously found by (26) or its modifications.

Appended herewith is a table showing, within the limits of error or of agreement of the data consulted, the remarkably close toeing-to-the-mark of enough substances to justify the above theoretical conclusions. For quite a number of substances no latent-heat figures could be found in references at hand; in which cases, for the purpose of comparison, the latent heat was computed by Trouton's Rule, viz.:

$$\frac{WL_b}{T_b} = \tau_t \text{ (a constant)} \quad (31)$$

where τ_t is the same for similar liquids. Referring (31) to (24) shows that

$$\tau = 17.42 \div \tau_t \quad (32)$$

Application of the Relationships

Discussing the general results of the application of the formulæ, it must be said at the outset that they checked much better than had been anticipated. Only three really glaring departures occur—those of formic acid, acetic acid, and acetic anhydride. But it is to be noted that τ approaches 0.75 from the tables for those three; which is following Trouton's assumption. Also, according to Trouton's Rule, if the latent heats of the three variants are correct as given, then the acetates and the formates should also prove exceptional; but those last, as seen, are among the best performers. Only one latent-heat reference each for formic acid and acetic anhydride could be found; but no less than three widely different values (all at the b.p., of course) were in evidence for acetic acid. Until something more definite regarding the latent heats of those discrepant liquids is forthcoming, the writer feels justified in believing that some peculiar difficulty is attached to the determination of that property of theirs.

The latent-heat data on sulphur were also hopeless (as is usual with $S_?$), and that particular instance was dismissed with the "stroke" of using for S_2 the Trouton Number (τ_t) of O_2.

The propionates, butyrates and volerates appear a little irregular, but a reasonable doubt may be cast upon the thermometry of the tables consulted for them, as well as upon the latent heats given.

In numerous instances of iso-compounds τ is checked better by the formula if the latent heat of the corresponding normal compound be substituted therein.

Only in two or three instances did there seem to appear any tendency to stray away from the value $\frac{1}{9}$ for ζ (in which cases the thermometry was clearly equivocal). The value of ζ begins to change, however, near the melting point. For example, $\zeta = \frac{1}{9}$ for water from 50 deg. (cf. K. & L., p. 40) to the critical temperature. Below 50 deg. ζ changes. That was to be expected from the fact that the present analysis assumes an unsaturated vapor.

Some of the rather pleasing results obtained are the apparent agreement of the gases of extremely low boiling point, of niton (radium emanation), and the figures for arsenic trioxide. The last is a subliming substance, and no boiling point has been found for it heretofore. A theoretical boiling point was, therefore, deduced for As_2O_3 by determining τ from simultaneous equations, thus:

$$\tau = \frac{\ln T_p - \ln T'_p}{\sqrt[7]{p} - \sqrt[7]{p'}} \quad (33)$$

Then, having τ, the theoretical value of T_b is obtainable from (12); proving to be 650.1 deg. abs. or 377 deg. C. Using that value gives the proper agreement, and the check for τ (against $AsCl_3$) is very close, considering. But what to do with carbon dioxide is a question.

The desirability of using the most positive data obtainable should be emphasized, or in the case of having several authorities, of striking a most probable mean (if necessary, drawing an average curve), it being also advisable, when a lone table is in doubt, to plot a curve which will show whether or not the tabulated data give all points on or very nearly on a smooth curve: e.g., plot a curve between x = mm. and $y = t$ from the table cited for m-amidoxylene. In the heading (p. 42) to their vapor-tension tables Kaye and Laby advise caution: "The thermometry is in many cases somewhat dubious."

Some of the earlier investigators performed monumental labors in producing tables and in working out interpolation formulæ; yet more modern workers, notably Ramsay and Young, with advantage of more

refined methods and apparatus and using stricter criteria, have obtained results that in quite a number of instances, especially at extreme pressures and temperatures, differ very appreciably from those of their predecessors. But it is wonderful, indeed, how much, aside from laying foundations, those searchers of the middle nineteenth century accomplished!

No attempt, therefore, has been made to give long-drawn-out accuracy either to the numerical values in the foregoing equations or to the figures in the table, owing, as just explained, to certain doubts about single-source data and to the disagreement, sometimes close, sometimes wide, of the authorities consulted for multiple-source data. The main thing is a desire to point out that here is a case wherein all liquids—whether mercury, sulphur, cadmium, xenon, water, ether, alcohol, normal compounds, iso-compounds, or what not—apparently follow the same law; which, naturally, leads one to believe that similar general laws exist for other property variations (or for the properties themselves) —such as, for example, variation with temperature of latent heat of vaporization, of viscosity, etc.

Calculations With the Williamson Formula

By Wallace Savage

Some months ago Mr. Williamson contributed his modification of Bertrand's empirical vapor pressure formula in editorial correspondence. Publication of it was withheld until the present time because it did not seem to offer sufficient aid to the overburdened-with-computations engineering profession. However, a new formula, as subsequently developed, can readily be worked with by means of a ln-log slide rule or an alignment chart having similar scales together with a special ninth root scale. Such a chart was designed by the writer and is included herewith.

Upon inspection of it, the reader will observe first the three equidistant scale lines X, Y and Z. Z and X are simple 6-in. log scales and Y has a log scale unit one-half as long, the initial points of the units being in line (1.00, 100 and 100). It is mathematically evident[1] that any straight line connecting an X number with a Z number will give the product of the XZ numbers on Y. Thus, 150 connected with 2 intercepts 300 on Y.

In the formula $\tau(P^{\frac{1}{9}} - 1) = \ln T/T_B$, the values of tau, being simple, are assigned directly to the Z scale. Values of the expression $(P^{\frac{1}{9}} - 1)$ are then computed and scaled at any convenient intervals above X on the the three lines 1, (Values of P 1.002 — 1.02 and 0.998 — 0.098 atmospheres); 2, (1.2 — 2.0 and 0.98 — 0.50) and 3, (1.2 — 100 and 0.83 — 0.005). Thus on the third line, 2 atm. and its reciprocal 0.5 are placed at $(2^{\frac{1}{9}} - 1)$ or $(1.08 - 1) = 0.080$, or 80 as expressed in the X scale units. Ln T/T_B are then scaled in a similar manner over Y on the three lines 1, 2 and 3 so as to be equidistant from Z and the corresponding P lines. Thus four separate alignment charts are obtained in a stack having the Z scale in common.

Upon making many calculations on liquids having known vapor pressures, it was found that the formula was very accurate at temperatures above the boiling point. Very large relative errors were found at lower temperatures, making it seem necessary to vary zeta or tau of the original formula. The latter seemed the more logical because tau is inversely proportional to W, the molecular weight of the liquid, which increases with polymerization, and L_B, the latent heat of evaporation, which also increases. The following data on water and benzol may be taken as typical:

WATER $T/T_B = T/373$

Deg. C.	370	250	200	150	70	40	20	0
T/T_B	1.72	1.40	1.27	1.13	0.92	0.84	.785	732
Press. Atm.	207	39.1	15.3	4.85	307	073	023	006
Cal. Tau	0.67	0.67	0.67	0.67	0.67	0.52	0.47	0.43

BENZOL $T/T_B = T/353.4$

T/T_B	1.49	1.35	1.20	.976	0.89	.833	.776
Press. Atm.	29.3	14.0	5.70	0.72	238	.098	035
Cal. Tau	0.89	0.89	0.89	0.65	0.67	0.63	0.57

Thus readings for water on the chart are correct with tau at 0.67 on Z for all points connecting it with the T (1) — P (1), T (2) — P(2) and T(3) — P(3) scales excepting from 0.30 to 0.005 on the lower side of P(3). However, if a point opposite 0.71 and one-third distant to the T(3) scale is taken, it will be found to determine these lower temperature ratios and pressure readings to a fair degree of accuracy.

The reader is cautioned not to get his scales mixed, bearing in mind that he has four separate and distinct alignment charts, the T and P scales of which have reciprocals, which are always to be used together. The X, Y and Z chart is given for use in the simple multiplications and divisions required in calculating millimeters, absoulte boiling fraction temperatures, etc.

The table of constants included here has two tau values, the first as determined empirically from known vapor pressures and the second from the substitution of L_B in the formula for tau. Where molecular dissociation occurs, the values of tau tend to increase greatly. To make the formula and chart 100 per cent reliable, it will be necessary to have empirical tau values throughout the entire range of temperature to be considered.

Problem Solutions

What is the vapor pressure of mercury at 450 deg. C.? The absolute temperature is first found by adding 273, giving 723 deg. for T_p. Upon looking through the constants of the elements in the first column, the absolute boiling point of mercury is found to be 630 deg. and tau 0.80. The ratio of T_n to T_B is then found to be 1.15 by aligning 630 on X with 723 on Y and taking the point of intersection on Z of this line. The pressure is then found by aligning 0.80, the value of tau, on Z with 1.15 on T(3), the point of intersection on P(3) giving the pressure as 4.4 atmospheres. This is readily converted to millimeters of mercury by aligning 760 on X with 4.4 on Z, giving a line that intersects Y at 3340. Upon looking up the determined mercury vapor pressures in Landolt and Börnstein Tabellen, page 376, five values are given as follows:

Regnault	450 deg. C.	3384.4 mm.
Hertz		3229.
Ramsay & Young		2996.1
Jewett		3245.0
Young		3150.5

If it had been desired to know to what temperature mercury would have to be heated to give a pressure of 10 atmospheres, the procedure would be: Align 10 on P(3) with 0.80 on Z and read 1.255 on T (3). Align 630, the T_B of mercury, on X with 1.255 on Z and read 790 on Y. Then 790 minus 273 gives the temperature as 567 deg. C.

In conclusion, it may be well to point out that the three P scales could have been made to read in any pressure units directly. The T scales can be scaled for any given boiling point liquid, thus forming a direct reading graphical chart of vapor pressures.

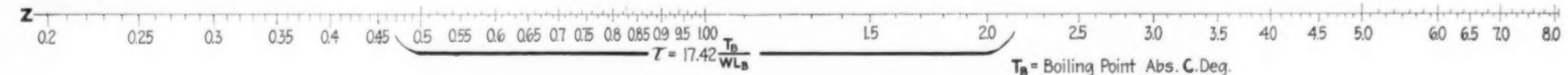
[1] For a geometrical proof and discussion, see Lipka, Graphical and Mechanical Computations, p. 45.

WILLIAMSON FORMULA CONSTANTS AND AN ALIGNMENT CHART FOR GRAPHICAL COMPUTATION

	T_B	τ	τ_L	L_B
Hydrogen	20	1.4	1.4	123
Sodium	1,150	1.1	.....	.....
Potassium	1,030	.....	0.78	592
Magnesium	1,390	.....	.....	.....
Aluminum	2,470	.....	.....	.....
Tin	2,540	0.7	.....	.....
Lead	1,800	0.8	0.80	450
Bismuth	1,690	.....	0.60	234
Arsenic	890	0.55	.....	.....
Phosphorus	560	1.1	0.60	130
Nitrogen	79	0.96	0.96	50
Oxygen	90	0.85	0.84	58
Sulphur	717	0.84	0.84	232
Chlorine	239	0.86	0.88	67
Bromine	332	0.80	0.80	45.6
Iodine	458	0.79	0.80	39.4
Manganese	2,170	.....	.....	.....
Chromium	2,470	.....	.....	.....
Iron	2,720	.....	.....	.....
Copper	2,580	0.65	.....	.....
Zinc	1,180	0.77	0.80	401
Silver	2,230	0.71	0.77	480
Cadmium	1,040	0.80	0.80	203
Gold	2,800	0.79	0.78	318
Mercury	630	0.80	0.80	68
Water	373	0.67	0.67	537
Hydrogen sulphide	211	0.85	0.86	126
Hydrochloric acid	190	0.77	0.74	122
Hydrobromic acid	204	0.84	.....	.....
Hydriodic acid	238	0.87	.....	.....
Ammonia	240	0.74	0.72	341
Nitrous oxide	183	0.85	.....	.....
Nitric oxide	123	0.66	.....	.....
Nitrogen tetroxide	295	0.54	.....	.....
Nitrogen pentoxide	320	0.80	.....	.....

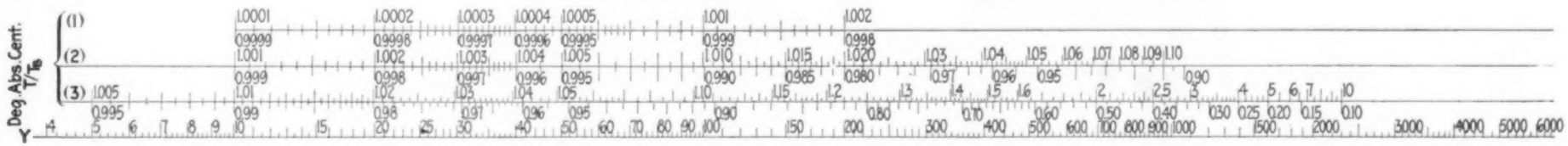
	T_B	τ	τ_L	L_B
Arsenic trioxide	650	0.57	.....	.....
Sulphur dioxide	263	0.76	.....	.....
Phosphorus trichloride	349	0.85	0.85	52
Arsenic trichloride	403	.....	0.56	70
Boron trichloride	291	0.85	0.85	51
Silicon tetrachloride	331	0.85	0.85	40
Tin tetrachloride	387	0.85	0.85	30
Mercuric chloride	576	0.65	.....	.....
Mercurous chloride	656	0.54	.....	.....
Nickel carbonyl	316	0.85	.....	.....
Methane	108	0.9	0.88	134
Ethane	188	0.9	0.88	124
Propane	228	0.9	.....	.....
Butane	274	0.89	.....	.....
Pentane	309	0.88	0.99	75
Isopentane	301	0.85	0.88	85
Hexane	342	0.85	.....	.....
Heptane	371	0.84	0.87	74
Octane	398	0.82	.....	.....
Decane	446	0.76	.....	.....
Ethylene	170	0.78	.....	.....
Acetylene	188	0.83	0.83	153
Methylalcohol	338	0.68	0.68	269
Ethylalcohol	351	0.64	0.64	206
Propylalcohol	370	0.66	0.65	164
Isobutyl alcohol	381	0.66	0.65	137
Isoamyl alcohol	403	0.66	0.66	120
Methyl chloride	249	0.84	0.88	96
Chloroform	334	0.83	0.83	59
Carbon tetrachloride	350	0.85	0.85	46
Ethyl chloride	287	0.84	0.84	92
Trichlorethane	347	0.82	0.82	55
Dichlorethylene	420	0.77	0.77	57
Pentachlorethane	435	0.82	0.82	46
Hexachlorethane	458	0.77	0.77	44

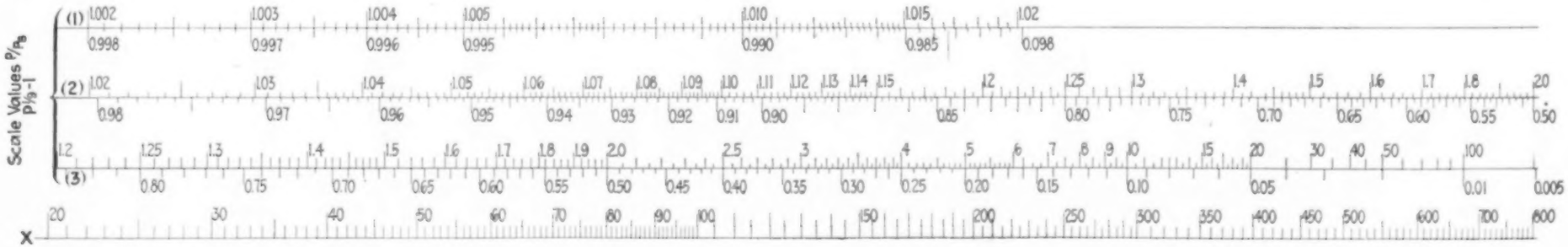
	T_B	τ	τ_L	L_B
Chlorbenzene	405	0.84	0.84	75
Brombenzene	429	0.84	0.84	56.5
Bromnaphthalene	554	0.79	.....	.....
Ethyl bromide	311	0.85	0.85	58.6
Ethylene bromide	405	0.85	0.85	43.8
Bromal	447	0.76	.....	.....
Ethyl iodide	345	0.82	0.82	47
Iodobenzene	462	0.82	0.82	48.2
Fluorbenzene	358	0.85	0.84	77
Cyanogen	252	0.79	0.73	115
Cyanogen chloride	289	0.75	0.74	110
Carbon disulphide	318	0.86	0.86	85
Ethyl ether	308	0.84	0.84	87.5
Acetone	330	0.79	0.79	125
Ethyl acetate	350	0.80	0.80	86
Proplyl acetate	374	0.84	0.84	76
Etnyl butyrate	393	0.78	0.81	71.5
Benzene	353.4	0.825	0.825	95.5
Toluene	384	0.81	0.861	84
o-xylene	415.6	0.8	0.864	79
m-xylene	412	0.8	0.864	78.3
p-xylene	410.5	0.8	0.864	78
Nitrobenzene	481	0.778	0.751	90.5
o-nitrotoluene	493	0.77	0.751	83.3
m-nitrotoluene	497	.....	0.751	84
p-nitrotoluene	512	0.77	0.751	86.5
m-nitroxylene	517	0.77	0.751	78.4
Aniline	457	0.75	0.751	113.9
o-toluidine	472	0.77	0.751	102
m-toluidine	476	0.72	0.751	103.1
p-toluidine	475	0.77	0.751	102.7
m-amidoxylene	491	0.77	0.751	94
Phenol	456	0.70	.....	.....
Naphthalene	491	0.75	.....	.....
Anthracene	624	0.75	.....	.....



T_B = Boiling Point Abs. C. Deg.
L_B = Latent Heat Evaporation
W = Molecular Weight
P = Pressure in Atmospheres
e = 2.718, Natural Log, Base

Vapor Pressure - Temperature Alignment Chart
Based on Formula $\frac{T}{T_B} = e^{\tau(P^{1/8}-1)}$





Copper and Magnetite in Copper Smelter Slags—II

Chemical and Microscopic Examination of a Series of Representative Slags, Showing How Copper Losses Occur, the Relation of Magnetite to Copper Loss, the Behavior of Converter Slags in Reverberatory Furnaces and Suggestions for Reducing Copper Slag Losses*

BY CHARLES G. MAIER AND G. D. VAN ARSDALE

IN THE first part an attempt has been made to point out certain relationships between magnetite in slags and copper loss, which have been summarized in the final part of this article to form the basis of a tentative rational theory to account for the mechanism of such co-ordination. Before proceeding to this matter, however, the generality of the conditions as described above should be proved to be prevalent in the usual matte-smelting process.

In Table III are shown the results of the application of the silver nitrate method to various slags from smelters other than those connected with the Phelps Dodge Corporation. The results are more or less self-explanatory, for on examination of the table it does not seem justifiable to conclude that the amount of dissolved copper is constant for all slags. The amount of pellet copper shows considerable variation, indicating varying degrees of efficiency of settling, but it is to be noted that the average deviation from the mean content of pellet copper, however small in amount, is nevertheless about equal to the variation observed in the content of the dissolved copper.

Despite the impossibility of proving constancy of dissolved copper for all slags examined, there is no doubt that a distinct similarity exists among these figures, and it seems fair to state that for all samples examined there remains the general classification as to form and content presented in our previous work; of the total copper present in reverberatory slag, a part, usually slightly less than 50 per cent and with an average magnitude of 0.15 per cent, consists of prills of sulphide, whereas the remaining copper is apparently in the dissolved form as sulphide and averages 0.20 per cent.

The microscopic similarity of all slags examined is even more striking than the similarity of quantitative results gained by the use of the silver nitrate method for dissolved and pellet copper. The visual uniformity of the major structure of the slags will be apparent from an examination of a few photographs appended in Figs. 31 to 38. The observation of all samples examined confirms the generality of the following statements.

Mattes as examined show identical two-phase structures consisting of iron sulphide constituent and copper sulphide constituent.

Reverberatory and blast-furnace slags show inclusions of copper sulphide globules approaching the constitution of white metal and present in amounts as specified in Table III. Attachment of gas bubbles is found in all slags for at least a portion of these globules and the disappearance of the iron sulphide phase or its separation from the copper sulphide globules is common to all samples examined.

On crystallization no oxide or silicate forms of copper have been recognizable, but there is considerable variation in the crystalline structure of the silicate phase. In all cases of reverberatory slags the formation of magnetite crystals on solidification is common and, so far as observed, universal.

TABLE III. DISTRIBUTION OF COPPER CONTENT OF TYPICAL SLAGS

No.	Name of Smelter	Per Cent Total Cu	Per Cent Cu as Pellets	Per Cent Cu as Dissolved	Per Cent Total Cu as Dissolved
1	Copper Queen blast furnace	0.35	0.19	0.16	45.7
2	Copper Queen reverberatory	0.25	0.08	0.17	88.0
3	Morenci blast furnace	0.35	0.23	0.12	34.3
4	Old Dominion blast furnace	0.30	0.15	0.15	50.0
5	Copper Queen reverberatory special	0.31	0.09	0.22	71.0
6	Copper Queen reverberatory converter test	0.28	0.06	0.22	78.6
7	United Verde blast furnace	0.34	0.15	0.19	55.9
8	Arizona Copper Co., reverberatory No. 1	0.37	0.16	0.21	56.8
9	Arizona Copper Co., Reverberatory No. 2	0.40	0.20	0.20	50.0
10	Arizona Copper Co., Reberberatory No. 3	0.40	0.15	0.25	62.5
11	Arizona Copper Co., reverberatory No. 4	0.32	0.08	0.24	75.0
12	Calumet & Arizona Copper Co. reverberatory	0.23	0.05	0.18	78.2
13	El Paso Smelter, reverberatory No. 1	0.46	0.21	0.25	54.4
14	El Paso Smelter, reverberatory No. 2	0.38	0.13	0.25	64.8
15	A.S. & R. Co., Hayden Plant, reverberatory	0.34	0.23	0.11	32.4
	Average	0.339 ±0.05	0.144 ±0.05	0.195 ±0.04	

Converter slags have sulphide globules similar to white metal usually constituting the major portion of the total copper content, and magnetite crystals formed during the fused state are observed in all cases.

No chemical relationship between copper content and slag constitution can be discerned. In taking up a comparison of slag samples from various smelters it was thought that the ability to distinguish dissolved and suspended copper in slags should be a valuable tool in discovering any such relationship which might exist, but a critical examination of the specific results obtained, as tabulated in Table IV, shows no adequate explanation for observed behavior.

SUMMARY OF FACTS

In spite of the possibility of some repetition, the following summing up of our experimental evidence may be of interest in connection with the theory which we wish to develop concerning the relationship of magnetite and copper in slags.

It has been found that copper matte-smelter slags contain their copper content in two forms usually about equal in amount, one of which consists of sulphide inclusions mechanically retained by the slag, the other being in an apparently dissolved form (at least not microscopically visible) which certain chemical aspects of the slag seem to fix, as also sulphide. But it has been also universally found that the pellet of mechanically held sulphide seldom retains the form of its original matte source, but instead loses its iron constituents (compare Figs. 36 and 37). This separation is accompanied by signs of chemical reaction, two products of

*For Part I, see CHEM. & MET. ENG., vol. 22, No. 24, p. 1101.

TABLE IV. COMPARISONS OF CHEMICAL ANALYSES AND COPPER CONTENTS OF TYPICAL SLAGS

No.	Slag	Per Cent Cu	Per Cent Dissolved Cu	Per Cent Pellet Cu	Per Cent SiO_2	Per Cent Al_2O_3	Per Cent CaO	Per Cent CaO +MgO	Per Cent S	Per Cent FeO	Ratio S/Cu
1	Copper Queen blast furnace	0.35	0.16	0.19	36.0*	11.0*	.....	7.0*	....	38.0*	....
2	Copper Queen reverberatory	0.28	0.22	0.06	40.76	11.43	4.88	7.61	0.41	37.56	1.46
3	Morenci blast furnace	0.30	0.15	0.15	35.0*	10.0*	.....	18.0*	....	34.0*	....
4	Old Dominion blast furnace	0.36	0.13	0.23	37.0*	9.0*	.....	16.0*	....	34.0*	....
5	United Verde Extension	0.34	0.19	0.15	43.86	5.55	12.81	13.53	0.37	34.32	1.09
6	Arizona Copper Co., No. 1	0.37	0.21	0.16	39.98	11.70	3.46	5.89	0.52	39.30	1.40
7	Arizona Copper Co., No. 2	0.40	0.20	0.20	38.80	11.38	3.07	5.31	0.40	42.35	1.00
8	Arizona Copper Co., No. 3	0.40	0.25	0.15	41.35	11.45	6.14	8.65	0.29	34.81	0.83
9	Arizona Copper Co., No. 4	0.32	0.24	0.08	41.69	11.71	6.03	8.33	0.25	36.36	0.78
10	Calumet and Arizona	0.23	0.18	0.05	42.70	6.56	6.52	8.19	0.73	39.96	3.10
11	El Paso, No. 1	0.46	0.25	0.21	41.04	5.88	5.68	7.39	0.40	42.87	0.87
12	El Paso, No. 2	0.38	0.25	0.13	41.75	6.44	5.16	6.41	0.58	44.31	1.50
13	A. S. & R., Hayden	0.34	0.11	0.23	37.22	6.78	15.02	16.63	0.47	38.27	1.38

*Estimated approximate average.

which may be distinguished. The first of these is a gas which must be, if its origin is in matte, sulphur dioxide, and secondarily, in extreme cases of rather unusual occurrence, the appearance of minute globules of metallic copper.

Experiments with the addition of converter slag to reverberatories have shown both chemically and visually through the microscope that there is connection between magnetite (ferric iron) and a portion of the copper loss, i.e., the globule content. The amount of the latter is proportional to the oxidizing strength of the slag usually indicated by the ferric iron and magnetite content.

The dissolved copper content representing the remainder of the copper is unaffected in total amount by the addition of converter slag to reverbertory, and consequently by the slight increase of oxidizing activity. If the dissolved form exists as sulphide, this fact proves that equilibrium is very closely approached.

Theory of Relationship Between Magnetite and Copper Loss in Slags

The facts summarized above lead to the supposition that in considering the process of reverberatory smelting in reference to copper loss, four types of phenomena or fields of action should be considered. These types are indicated graphically in the chart, Fig. 39, and are separated there by dotted lines, although it is not meant that these actions are separable physically or represented by actual spatial zones of the furnace. All of the actions presented probably occur simultaneously to a greater or less degree, but it is not impossible that actual spatial separation in a specially designed furnace might not be theoretically desirable.

The first action in smelting to be considered, from the standpoint of copper loss, is primarily the change of physical state due purely to fusion. The primary formation of matte and slag is essentially and inherently a physical transformation, and any reactions involved are of a metathetical type and do not represent any ultimate change in total slag and matte, nor do they seem to be the source of copper loss. For example, we know that the original roasted calcine fed to the furnace may contain part of its copper content as oxide, but the amount of oxide truly fed to the furnace is not easily determined. A typical sample, as taken for analysis, may contain 10 per cent copper with 3 or 4 per cent acid soluble, but the method of sampling, as compared to the practical handling of calcine where it is conveyed in large quantities directly, and with a minimum cooling, from roaster to reverberatory, does not enable one to state definitely that the hot calcines, as usually fed to the furnace, do contain this amount of oxide. Even if the calcine does contain this amount of oxide copper, however, it does not have effect on the final copper loss, since all the copper not in slag (the copper content of the slag is indicated by our work to be sulphide) is finally found in the matte and the reaction $FeS + Cu_2O = Cu_2S + FeO$ must have occurred if the final condition is to be accounted for. This reaction is obviously the reason for the absence of copper oxide forms in the slag, but does not affect the final copper loss except in so far as it inhibits the formation of oxide forms.

While it is possible that some chemical oxidation does occur during the time in which the change from solid to liquid state is taking place, this action is purely secondary and is not truly an essential part of the matte-smelting process as carried on in the reverberatory. Chemical action, except the roasting mentioned above, is at a minimum in the solid charge. As far as *copper* loss is concerned, chemical reactions are not the source of any loss at this stage of the process, and it it justifiable to assume the first and essential action of smelting in reverberatories to be a purely physical change of state, whose only result on the final copper content is the saturation of the slag phase with sulphides and the entrainment of small amounts of sulphide globules in the slag medium.

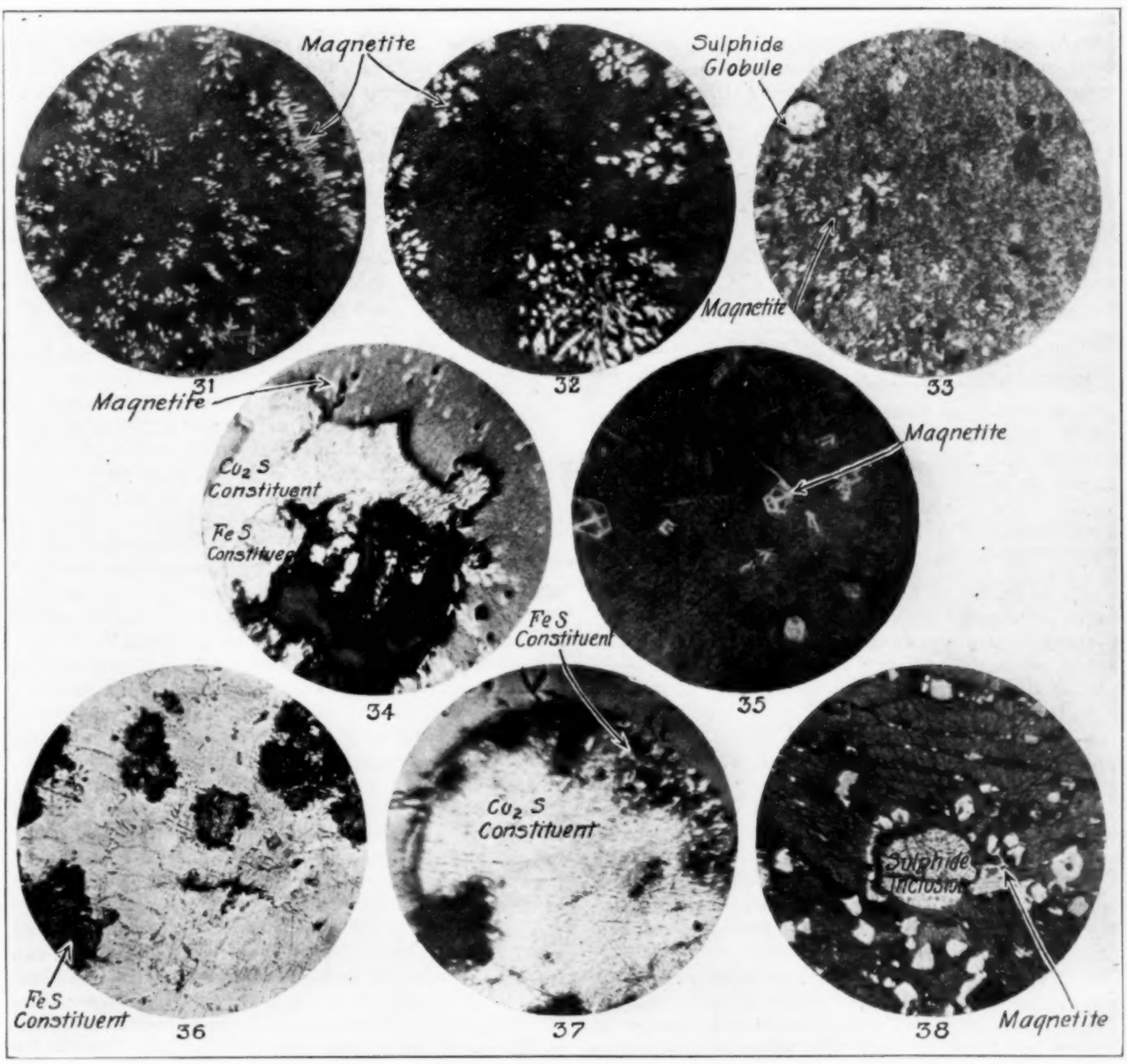
Having once attained the molten condition, aside from the purely mechanical separation in whole or part of the matte and slag components, the chemical activity of the charge is enormously increased by the change of state, and a new condition, marked *B* in the chart, prevails in which chemical equilibrium tends to find its level. The matte, more or less protected by the fused silicates, does not have opportunity for direct oxidation to the same degree as the slag. In the latter the ferrous oxides or silicates are oxidized to ferric iron, thus increasing the content of the latter due to its original presence in the charge. By this means the fusion aids in the formation or crystallization of magnetite. It has been shown that the magnetite has great tendency to settle through the slag as soon as crystals of any appreciable size are formed, and inevitably thus comes in contact with the matte constituting the bottom of the fluid portion. Large crystals of magnetite are not visible in the usual reverberatory sample (cf. Figs. 2, 8 and 14)[2] and their absence can be explained only on the basis of this settling action, for the formation of minute crystals on cooling and solidification shows that the slag is saturated with ferric iron. Moreover, since the total effect of the reverberatory furnace as a chemical apparatus is at least some little increase in oxidation, magnetite crystals must be continually forming in the molten slag. Since crystals formed during the molten condi-

[2]See pp. 1102, 1103 and 1104.

tion are not visible in the final sample, (e.g., Figs. 6 and 12 show[3] only crystals formed in solidification), it must be true that these crystals have been disintegrated as rapidly as they were formed. Fortunately magnetite is wet by fused sulphides (Figs. 29 and 30)[4], and its life at the bottom of the slag in contact with matte is short. Pictures shown above such as Figs. 27 and 28 indicate clearly the progressive character of the ferric iron or magnetite reacting to be fluxed through the agency of the sulphides. The slowness of the fusion in the viscous slag medium prevents the instantaneous reduction of the magnetite in reverberatory slags, and thus permits photographs of the actual mechanism by which equilibrium is attained to be taken in solid specimens. This is consistent with the absence of visible magnetite in the more thoroughly mixed blast-furnace slags. Accidental contact between sulphide globules in suspension and magnetite is rare in reverberatory slag, but more possible in the blast furnace.

Upon contact with the body of the matte below the slag, the magnetite reacts, setting free sulphur dioxide. The gas rises and carries with it the sulphide globules which constitute the second portion of copper loss in the slag. This loss is inherent in the reaction of sulphur elimination and the variation of metal loss in slag under otherwise constant conditions of charge and temperature must be due to changes in this reaction, loss by solution being normally constant. This action is the essence of stage *C* (Fig. 39), where chemical equilibrium of magnetite-sulphide oxidation approaches a condition balanced by the physical action of gravity, mixing, etc. *B* and *C* together are a dynamic condition which becomes cyclical for all usual phases of furnace operation.

[3]See pp. 1102 and 1103.
[4]See p. 1106.



FIGS. 31 TO 38. SLAGS FROM VARIOUS COPPER SMELTERS

Fig. 31. El Paso smelter, reverberatory slag. 110 ×. Fig. 32. Hayden smelter, reverberatory slag. 110 ×. Fig. 33. Calumet and Arizona smelter, reverberatory slag. 110 ×. Fig. 34. Arizona Copper Co. smelter, reverberatory slag. 110 ×. Fig. 35. Same specimen, showing detail of magnetite particles. 700 ×. Fig. 36. United Verde Extension, blast furnace matte, H_2SO_4 etching. 110 ×. Fig. 37. United Verde Extension, blast furnace slag. 110 ×. Fig. 38. United Verde Extension, converter slag. 110 ×.

The last phenomenon, *D*, is the purely mechanical one of settling, and although this may primarily be regarded as a direct and necessary sequence of the change of physical state at *A*, it should, nevertheless, be considered as a separate action because it is so profoundly affected by the intervening and previous chemical and physical equilibria of *B* and *C*. The silicate portion thus acts as a medium for the stabilization of sulphur elimination in which ferric iron formed at its gas contact surface becomes magnetite, settles, reacts with matte to eliminate sulphur as dioxide, and to be itself redissolved and fluxed.

The history of the metal loss in reverberatory slags, as influenced by the four phases of smelting as classified in Fig. 39, should be apparent. The original change of physical state at *A* is the initial cause of two sources of copper loss. The first portion is the direct solubility of a part of the sulphide in the silicate fusion. This part is constant in amount for any normal condition of temperature and composition and is materially unaffected by the subsequent equilibria. As a necessary consequence of the action of melting, entrained sulphide globules are formed. These sulphides should not be normally expected to float in the slag unless affected by some subsequent buoyant effect. As far as density and viscosity are concerned, there is no reason why complete separation of such entrained globules should not be obtained merely through the medium of increasing the time of settling.

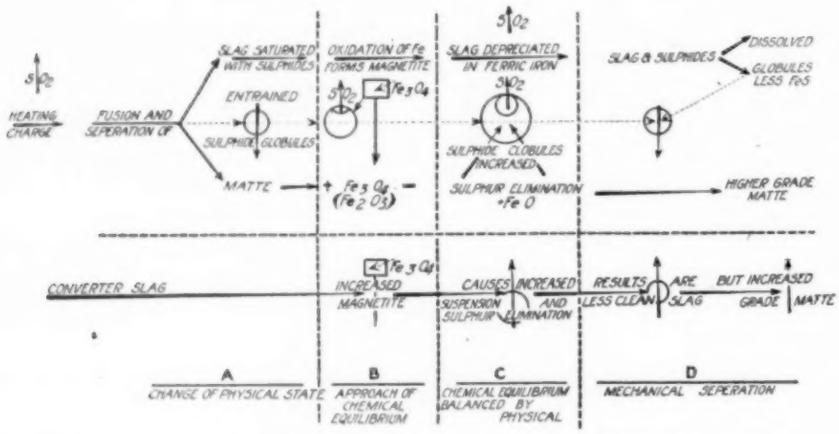


FIG. 39. RELATIONSHIP OF MAGNETITE AND COPPER LOSS IN REVERBERATORY SLAGS

The persistence of entrained and floated globules of sulphides is due to the second action *B*, that of the approach of chemical equilibrium. The manner in which the formation of magnetite causes the continual flotation of globules of sulphide has already been discussed above and needs no further comment except to point out that as long as the silicate portion of the slag is in contact with the furnace gases or any oxidizing condition there will be a continuous suspension of sulphide globules due to this action.

The extent to which contact of magnetite with matte can cause the formation of suspended globules depends obviously upon the rate at which the original magnetite is formed and upon the speed with which it can come in contact with the matte. A limit is reached in state *C*, where the suspension and sulphur elimination are balanced by the physical equilibrium of settling and diffusion, and this represents the final state of the slag as obtained.

The rôle played by converter slag in disturbing slightly the balance of normal conditions, as indicated in the previous paragraph, can now be understood. Its magnetite content increases somewhat the total amount of ferric iron, which is the cause of sulphur elimination in the molten mass, as distinguished from sulphur elimination by roasting action, which is confined to the solid state before fusion. The normal effect of increase in magnetite is an increase in the extent to which sulphur dioxide is produced at the matte surface and consequently results in more suspension of copper globules (sulphide) throughout the slag. At the same time the grade of matte is necessarily increased.

To secure finally the most efficient settling or recovery of sulphides from slag, the modifying effects of iron playing its shuttle game from magnetite crystals to ferrous silicate melts must be considered in its practical aspects.

Certain Practical Aspects of Results

If present and previous work has necessarily been of more theoretical than direct practical application, it has at least indicated rather definitely the answers to some problems which present themselves in considering methods for decreasing the metal loss in copper smelting slags.

In the blast-furnace or reverberatory slags the classification of the losses into two normal classes of dissolved and suspended sulphide globules enables direct prediction of the possible methods for securing decreased loss. Dissolved loss, whether it be due to true or colloidal solution, can only be controlled internally by variation of the temperature or constitution of the melt, or externally by the addition of such reagents as might cause a depression of the solubility by a common constituent (ion?) effect. In a practical way the criteria of satisfactory furnace operation and economy of flux, as well as limitations due to the original constitution of available ores, will tend to render improvement by change of constitution unlikely.

Depression of the solubility by the addition of external agents requires the use of sulphides. Iron is precluded because the slag is already saturated with its sulphide, and further addition could have no effect on the *dissolved* copper portion. Furthermore, the effect of the addition agent would be proportional to the amount added, and consequently no hope of the complete elimination of the dissolved constituent may be entertained, and no practical method whereby a saving of even any considerable amount of the dissolved copper is discernible on this basis.

The elimination of suspended copper globules would seem to have much greater practical possibility, even though the total amount of metal recoverable is limited by the small percentage present in this form. The results outlined above leave no doubt as to the conditions which must prevail to obtain a decrease. Both the initial formation of floating sulphide globules and the continuity of suspension are due to oxidation carried on through the medium of ferric iron and magnetite. Many persons, noting an increase of copper in slag as the grade of matte was increased, have imagined a direct

chemical relationship to exist between the grade of matte and metal loss, but this connection is not truly causative, being in fact a secondary action. Considering the dissolved content, since we know that the constitution of suspended globules approaches that of pure cuprous sulphide, the solubility of copper sulphide in the slag must approach a constant maximum corresponding to equilibrium in accordance with a fixed distribution ratio, one of whose phases approaches a pure material. This means that the grade of matte cannot affect the amount of dissolved copper by any solubility effect. An altogether different condition exists for the globule content. Any process of smelting to give a high-grade matte must necessarily be done under more strongly oxidizing conditions than that producing a low-grade matte, and an increase of suspension is inevitable, because it is just this oxidizing condition which is the source of suspended copper sulphide loss.

In the light of this reasoning, the extent to which the contact of matte and slag is under oxidizing conditions forms the major factor for determining the final copper content of the slag rather than any directly chemical relationship. The necessary conditions under which a saving of suspended copper may be made are clearly a matter of proper non-oxidizing settling, but it must be left to the practical smelter man to design suitable apparatus embodying the above principles for obtaining these conditions in a usable furnace.

Even more definite conclusions are deducible regarding the practical treatment of converter slag. If minimum copper content of slag is desired, the addition of converter slag to normally operated reverberatories is undesirable except under those conditions in which the mixing can be done throughout a zone sufficiently reducing to insure complete reduction of the magnetite. Unless the magnetite is completely fluxed in the presence of excess sulphides, an increased suspension of sulphide globules seems inevitable.

The effect of the addition of converter slag to reverberatories may be practically classified from either of two points of view, regarding the effect on the basis of the per cent saving of copper content of the original converter slag, or with respect to the effect on the original reverberatory slag to which the converter was added. Considering first the saving of copper content of the converter slag, the undesirability of making the addition under any other than completely reducing conditions may be shown by a simple calculation. The original converter slag may normally carry from 3 to 10 per cent of copper, the greater part in the form of suspended globules of white metal with occasionally small amounts of metallic copper. The average dissolved copper content of the converter slag is not nearly so constant as with other slags, but may be assumed to have an average maximum of 0.5 per cent. On addition of the converter slag to the reverberatory, the sulphide globule content of the former might be expected to be amenable to settling and recovery, but it is evident from our work that the recovery of the total globule content is only possible under the strictly reducing conditions mentioned above.

Now assume the normal copper content of reverberatory slags to be 0.40 per cent, of which 0.25 per cent exists as suspended globules and 0.15 per cent as dissolved. Since, as far as microscopic appearance and chemical behavior of the suspended globules in converter slag are concerned, they are exactly similar to those in reverberatory slag, we may assume that the suspension of the original converter globules when present in the mixed slag would certainly not be less than normal but will be greater than normal in proportion to the increase of ferric iron due to the admixture of unfluxed magnetite. A typical case would be represented by the addition of converter slag containing 3 per cent copper, 0.50 per cent of which is dissolved, and with a normal magnetite content of about 25 per cent. If this is now added to the extent of 10 per cent to reverberatory slag with an original 5 per cent magnetite content, the final mixed slag would contain $(5.0 \times 0.9) + (25.0 \times 0.1) = 7.0$ per cent. The suspension of sulphide globules is therefore increased in the ratio

$$(7.0 \div 5.0) \times 0.25 = 0.35 \text{ per cent.}$$

The total amount of the original content of the converter slag which is not recoverable even under the best conditions is therefore the sum of the new suspended copper plus the original dissolved

$$0.50 + 0.35 = 0.85 \text{ per cent} = 28.3 \text{ per cent of total copper.}$$

From the other point of view, with respect to the copper content of the reverberatory slag itself, according to the above calculation, the suspended copper would become 0.35 per cent, giving a total copper content of $0.15 + 0.35 = 0.50$ per cent. This represents an increase of 20 per cent of the total original 0.40 per cent content, whereas the percentage admixture is only 10 per cent. The increased loss due to the addition of the converter slag is greater than the per cent admixture, and the addition must be concluded to be unsatisfactory.

Although the above calculation emphasizes the disadvantages of mixing converter and reverberatory slags so long as reducing conditions do not prevail, it is fortunate that in practice there is always some reducing action at some point in the reverberatory despite the fact that the total effect is one of some oxidation. If it is essential to the routine operations of smelting to add fused converter slag to reverberatories, the practical ideal condition which should be aimed at is obviously to maintain a reducing zone in some part of any given furnace to which admixture is being made.

Better yet will be the results of smelting separately with a pyritic siliceous material, preferably to produce a low-grade matte, in order effectually to reduce the magnetite. Such a process has already been carried out at Anaconda[5].

Finally, the above considerations indicate the possibility that methods of concentration of converter slag other than direct smelting are worth considering, although the practical justification of any method of concentration will be affected by the extent to which the fluxing value of magnetite is usable in smelting by the maintenance of a preponderating reducing atmosphere.

Appendix

The method for the estimation of suspended and dissolved copper in slags by the use of dilute neutral silver nitrate solutions has been given in detail in a previous article and a complete discussion of its justification for this purpose need not be reproduced here. The beautifully definite manner in which it worked in the present instance gives, however, added weight to the consideration of its usefulness as a critical method in the examination of slags.

The determination of ferric iron in slags is a matter

[5]See *Trans.* February, 1920, Meeting of the American Institute of Mining Engineers and CHEM. & MET. ENG., vol. 22, pp. 231 and 347.

of considerable difficulty. Although the total iron is easily determined and an estimation of ferrous iron should complete the solution of the problem, there are two serious difficulties in the way of obtaining accurate results on silicates. These are:

(*a*) The necessity of disintegrating the slag without oxidation.

(*b*) The harmful effects of sulphides in oxidation and reduction reactions involving the state of the iron prevent accurate determinations of ferric iron in their presence.

A number of methods of disintegration have been proposed for determining the ferrous iron in silicates by Hillebrand[6], J. P. Cooke[7] and Doelter[8], based on the use of hydrofluoric and sulphuric acids in an atmosphere of

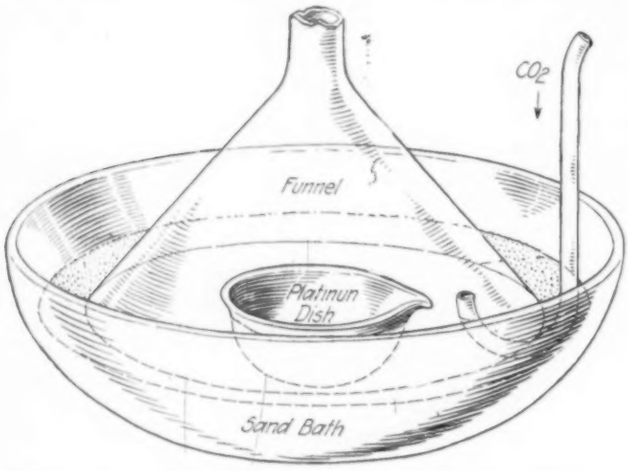


FIG. 40. APPARATUS FOR DISSOLVING SLAG WITHOUT OXIDATION

carbon dioxide. A composite method based on the recommendations of these authorities has been worked out as follows:

From ½ to 1 g. of slag sample ground to 100 mesh in porcelain was weighed out into a 25-c.c. platinum dish, 2 to 3 c.c. concentrated sulphuric acid was added and the whole stirred with a platinum wire. The dish was then immersed in an atmosphere of carbon dioxide over a sand bath, as shown in the illustration Fig. 40. Ten to 12 c.c. of concentrated hydrofluoric acid was added and gentle heat applied for a period of twenty to thirty minutes until, after frequent stirring with a platinum wire through the top of the neckless funnel, complete disintegration had taken place. The heat was then removed and after cooling the contents of the dish were washed into about 300 c.c. of water with warm dilute sulphuric acid.

If one endeavors to titrate for ferrous iron with permanganate in this solution, the presence of hydrofluoric acid remaining undistilled causes a very bad end point because of the reactivity of manganese fluoride toward permanganate. This condition was partially eliminated in the following manner:

Potassium carbonate and pure finely ground quartz in the proportion $4K_2O : SiO_2$ were melted together in a platinum dish to quiet fusion; the silicate thus formed was broken up and dissolved in a minimum of water, and sulphuric acid added until the liquor was quite strongly acid to litmus, thus precipitating gelatinous hydrated silicic acid and forming potassium acid sulphate. An amount of this solution and precipitate corresponding to about 3 g. silica was then added to each determination and the ferrous iron titrated directly with permanganate. Under these circumstances most of the hydrofluoric acid remaining is converted into potassium fluosilicate and the end point is considerably improved.

The determination of ferric iron by this method as the difference between the total and the ferrous iron is perfectly feasible, but the actual amount determined will probably be somewhat less than the true content because of the sulphides present in the slag. For the present work, however, in default of absolute accuracy of results, if the results are comparable they could obviously be made the basis of a theory concerning the relationship of ferric iron to the copper content of slag. The justification of the use of the method depends then on the fact that the total sulphide present in the samples analyzed varies in amount less than a few tenths per cent, whereas several per cent of iron are being determined. Consequently the small practically constant error which is involved, due to the presence of sulphides, has been deemed negligible for present comparative purposes.

[6]Bulletin U. S. Geol. Survey No. 176, 1900.
[7]*Am. J. Sci.*, 2nd series, vol. 44, p. 347, 1867.
[8]*Z. anal. Chem.*, vol. 18, p. 50, 1878.

Sulphuric Acid Industry in Japan

The following table gives some idea of the sulphuric acid industry in Japan:

	Production lb.	Yen
1912	218,460,500	2,118,960
1913	413,613,100	3,328,950
1914	472,905,000	3,004,220
1915	492,026,600	4,702,660
1916	781,425,520	10,844,860
1917	741,039,160	8,916,830
1918	1,269,200,000	14,250,000

Production for 1914, the year the war broke out, shows an increase of 60,000,000 lb. over the previous year but a decrease in value of 324,730 yen. Since then, however, the production has shown an increase, with a slight let-up in 1917. No exact figures are obtainable for 1919, but it is estimated that the production was not less than 1,300,000,000 lb.

EXPORT TRADE

	Kin	Yen
1914	3,386,760	140,348
1915	13,245,641	501,921
1916	25,008,955	1,517,617
1917	6,949,083	503,594
1918	5,862,000	408,450
1919	5,354,092	436,178

As seen from the above table, there was a considerable increase in the export of sulphuric acid in 1915 and 1916, probably due to increased exports to Russia. Since that time, however, the trade has been diminishing until in 1919 it fell to 5,350,000 kin, valued at 436,000 yen.

The principal countries to which Japan exports sulphuric are China, Dutch India, the Straits Settlements and Hongkong. In 1916, 17,000,000 kin of sulphuric acid valued at 1,000,000 yen was exported to Russia, representing 40 per cent in quantity and 60 per cent in value of the total export, but in 1917 the export to Asiatic Russia fell to 29,000 yen and in 1918 to only 200 yen.

Some quantity of sulphuric acid was exported to Sweden, Siam, the United States and Hawaii in 1915, but the export has ceased since 1916. In 1917, 90,000 yen of acid was exported to Egypt and 80,000 yen in 1918.

Legal Notes

By Wellington Gustin

Armour Fertilizer Works Not in Contempt

Judgment has been reversed, in the contempt case instituted by the State Solicitor General of the Atlanta circuit against the Morris Fertilizer Co., and involving the Armour Fertilizer Works, by the Supreme Court of Georgia. Action in this matter seeking to enjoin and abate the fertilizer works of these companies in Fulton County, Georgia, as a nuisance, was begun in December, 1917. In the court proceedings only the Morris Fertilizer Co. was named as defendant, and a temporary order was obtained restraining it "from permitting any poisonous or noxious gases or vapors to escape from or be carried beyond the ground owned by the defendant company, and upon which its plant is located." This order was subsequently modified, in 1918, to read "The defendant is restrained from permitting any gases or vapors to escape from or be carried beyond the ground owned by the defendant company, and upon which its plant is located, so as to constitute a nuisance, etc."

It appears that Armour Fertilizer Works was never joined as a defendant, but subsequent to the court order an agreement was entered into between the Solicitor General for Atlanta and both defendant Morris Fertilizer Co. and Armour Fertilizer Works in which the Armour Fertilizer Works agreed to abide by the terms of the injunction issued against Morris Fertilizer Co. Upon the application of the Solicitor General and by consent of the Morris company the contract, by order of the court, was made a part of the court record in the case. The Armour Fertilizer Works did not join in this application, and did not consent to the court's order.

Both Companies Cited for Contempt

Later the state filed an application for attachment against both the fertilizer companies for contempt of court by violation of the restraining orders, and the Armour Fertilizer Works was adjudicated a party defendant. Both of the companies demurred to the state's petition and their demurrers were overruled in the trial court, and they took the case, by error, to the Supreme Court of Georgia. Here this court held that the Armour company was not a party to the cause, and was not bound by the judgment of record therein, either (1) by voluntary contract, (2) by order of the court, or (3) by estoppel; and this is true, although the Solicitor General for Atlanta contemplated the filing of a separate suit against the company to enjoin its works as a nuisance.

On the application for attachment for contempt, the court said such a proceeding in which the defendant and one not a party to the case are joined as respondents, and in which acts of the defendant and that person are alleged to constitute, jointly and severally, a contempt, is not good because of misjoinder of parties defendant and misjoinder of causes of action.

Regarding the agreement between the parties, the most that can be said is that though the state contemplated filing a separate petition to abate the Armour factory as a nuisance, the contract was made in settlement of a contemplated suit. A controversy is not a suit, and an agreement with reference thereto, though intended as a final settlement thereof, is merely a contract, and not a judgment of the court. The Armour company could not be held to be a party defendant by estoppel, upon the ground that the making of the contract prevented the filing by the state of a separate suit against it, praying that its factory be enjoined and abated as a nuisance.

The judgment was reversed.

Oral Evidence Inadmissible to Transform Sale by Description Into One by Sample

Some important points of information for the trade have been brought out by the Appellate Division of the Supreme Court of New York in the action of the American Aniline Products, Inc., against Mitsui & Co., Ltd.

Aniline Products brought its action to recover on three contracts for the sale to Mitsui & Co., Ltd., of a quantity of dyes, which the exporter refused to accept or pay for. The latter admitted giving the orders, each of which was alike except as to dates, quantity of dyes and dates of shipment, and that the Aniline company accepted them. It was further admitted that the dyes should be packed in barrels of 400 to 500 lb. net each, instead of 100 lb.

Samples of Dyes Submitted

Mitsui & Co. defends on the ground that prior to the date of the orders, as it alleges, the Aniline company submitted to it a certain sample of dye, and offered to sell to it dyes according to such sample, and represented and agreed and warranted that deliveries of dyes under orders thereafter received from it would be equal in dyeing strength, color, quality and all other respects to the sample submitted; that relying upon this it gave the Aniline company its export orders for the dyes referred to in the complaint. Mitsui & Co. further alleged that when the Aniline company notified it of intention to deliver certain dyestuffs under the orders, an examination was made which showed the dyes did not correspond with the sample; that thereupon the dyes were rejected and Mitsui & Co. refused to accept delivery or pay therefor.

Upon examination of the writing and orders involved, it was found that such contained no reference to a sale by sample, nor did they contain any express warranty as to strength, color or quality. The important proposition in the case, therefore, was whether the exporter could show, by evidence outside the writings sued upon by the Aniline company, that the dyes were warranted to correspond in all respects with a sample.

Evidence of Sale by Sample Ruled Out

While oral statements will not be permitted to change or vary the terms of a written agreement, yet this rule of law does not operate to prevent one from showing a prior, independent and collateral agreement, said the court. Now, while the agreement alleged in the exporter's defense to the suit was a prior one, it is neither independent nor collateral, for it touched upon at least one element in the written order and agreement. That element was the quality of the article sold. The writing shows a sale by description, being "Amacid Blue Black KN," and therefore the obligation of the seller was merely to deliver goods to that description of

merchantable quality, ruled the court. In a sale by sample, the bulk must correspond in quality with the sample. To attempt to transform a sale by description into one by sample is to attempt to vary the obligation of the seller as to the quality of the article to be delivered. This cannot be done, said the court. (89 N. E., 365.) Therefore evidence as to a sale by sample was not permitted in evidence, as it would result in varying a written agreement by parol evidence.

However, the court held that upon the trial either party would be at liberty, by word of mouth, to define the term "Amacid Blue Black KN." The rule of law is that when a term of a written contract requires definition in order to make its meaning clear, and such definition is not found in the writing itself, it is always permissible to give that definition by extrinsic evidence. For such evidence does not vary the meaning of the writing, but, on the contrary, discloses the full meaning of the parties to the instrument.

Regulation Upheld for Computing Drawback Due Exporters

Section 22 of the act of Congress effective Aug. 27, 1894 (28 Stat., 509, 551) provides as follows:

"That where imported materials on which duties have been paid are used in the manufacture of articles manufactured or produced in the United States, there shall be allowed on the exportation of such articles a drawback equal in amount to the duties paid on the materials used, less 1 percentum of such duties . . ."

It is further provided in the section that the drawback due thereon shall be paid to the manufacturer, producer or exporter "under such regulations as the Secretary of the Treasury shall prescribe."

Under this section the National Lead Co. brought suit against the United States to recover the difference between the amount of drawback allowed by the Government to the company, as an exporter of linseed oil cake, and the amount to which it claims to be entitled.

The National Lead Co. imported large quantities of linseed upon which it paid a specific duty of 20c. per bushel of 56 lb. This seed, when treated by a simple process, yielded about 20 lb. of linseed oil and about 36 lb. of linseed oil cake to the bushel. The oil was much more valuable than the oil cake, the latter being composed of the solid substance of the seed and a small amount of oil not recovered, which made it valuable as a feed for stock. It is a byproduct and, except for the small amount of oil in it, would be mere waste. The company exported large quantities of oil cake derived from seed which it had imported and made demand for the drawback provided for by the act of Congress.

In rendering its decision on the case the United States Court of Claims found that:

"From Aug. 5, 1861, to the present time the practice of the Treasury Department, where several articles are manufactured from the same imported material, has been to calculate and to pay the drawback by distributing the duty paid on the imported material between such articles in proportion to the value and not in proportion to their weight, as well where the imported material paid a specific as well as where it paid an ad valorem duty. Such calculation and payment had been made under Treasury Department regulations."

The company appealed its case to the Supreme Court of the United States, which has just handed down its decision. The company claimed that the correct construction of the section requires that the drawback should be computed on the basis of the weights of the oil and oil cake derived by the process of manufacture from the seed, instead of on the basis of the values of the two products, as it was computed by the Government. Hence the question presented to the court was whether the department regulation is a valid interpretation of the statute.

The act provides that the drawback allowed shall be "equal in amount to the duties paid on the material used," less 1 percentum. Now, what was the amount of duty paid on the small amount of oil and on the large amount of solid substance, the hull and the fiber, which made up the exported oil cake? Was it substantially two-thirds of the total, determined by weight—on 36 of 56 lb.—or was it about one-fourth of the total as determined by the relative values of the oil and of the oil cake derived from the seed?

Supreme Court Upholds Regulation

The terms of the statute show that the contingency of having one kind of dutiable material, from which two or more kinds of manufactured products might be derived, is not specifically provided for. The statute, thus indefinite if not ambiguous, called for construction by the Treasury Department and the regulation adopted to cover such cases as here presented was commended and upheld by the Supreme Court.

It says that Congress did not intend that two-thirds of the duty should be returned when one-quarter in value of the manufactured product should be exported; or that the exporter should retain 20 lb. of oil, estimated to be worth about 7½c. a lb., derived from each bushel of seed, and recover two-thirds of the duty paid when he exported 36 lb. of seed cake, worth slightly more than 1c. a lb., derived from the same bushel of seed. But such results would follow if the contentions of the exporter were upheld.

This case is important in that it attacks a regulation of the Treasury Department which has had an extensive and long-continued application to imported and exported material other than such as are here involved.

Seller's Representations Amount to Warranty

The Supreme Court of North Carolina has ordered a new trial in the suit of Swift & Co. against I. M. Meekins and others. The plaintiff sued to recover on a note of defendant given for the purchase of fertilizer. Defendant set up a counter-claim for breach of warranty as to the quality of the fertilizer.

It appears that defendant purchased forty tons of fertilizer, analyzing 5-7-0, and ten tons of acid phosphate. Meekins testified that seller's agent, at the time of sale of the fertilizer, stated that it was as good as any of the same analysis sold to be used for cotton and corn, and was as good fertilizer as there was on the market, and that Swift & Co. would sell it cheaper on account of their output from their packing house. The Supreme Court said these statements amounted to a warranty as a matter of law. It is not necessary that the language should be intentionally false or that there should have been any purpose to deceive. The positive representation by a seller that the article sold possesses a certain value and certain qualities amounts to a warranty, and the purchaser may set up the breach of warranty and reduce the sum claimed by the difference between the contract price and the actual value, although there was no deceit in the sale.

Scientific Control of the Filter Station—IV

A Discussion of Methods Used in Discharging Filter Cake From Presses—Points on Handling Difficultly Discharged Materials—Reverse Current Discharge—Use of Air, Steam, Water and Scrapers—Filtrate and Cake Capacity Ratings—The Economy Curve*

By ARTHUR WRIGHT, M.E.

DISCHARGING the cake is in many respects the keynote of efficiency in filter operation. Any type filter that cannot be operated so as to keep the cloths in a free filtering condition for recurring runs is not only inefficient but a makeshift. Let clarification, washing or drying be faulty and discharge satisfactory, the filters can still operate with a certain degree of economy. More filters are operating poorly by reason of incomplete or time-consuming discharge of the cake than for any other reason, and too many of them needlessly so.

The fundamental principle in discharging the cakes from filters using fabric as the medium is that the cake shall cleave away from the cloth. In filter press operation this is indicated by the cakes falling out of the frames as the operators move up the successive frames. In modern type filters it is demonstrated when the reverse current of a discharging agent—compressed air, steam, water, etc.—disengages the cakes from the cloths and allows the solids to fall by gravity or to be removed by a scraper. In sluicing discharge machines the principle is again proved when the water jet is able to sweep the entire cake away from the cloth.

Difficultly Discharged Materials

When handling materials that cannot be effectively discharged, those filters in which the cloth can be most easily removed and replaced by clean cloths are the best the market affords. Fortunately many materials hitherto resisting all methods of effective discharge are today, by reason of our better knowledge of the art, satisfactorily handled. There can be no refutation to the fact that inefficient operation of filters paves the way for substitute methods of clarification—decantation, flotation, centrifugating, etc.—and faulty discharging discredits filter operation most severely.

As was pointed out in the first article of this series, dense filter cloths are not good mediums for best filter operation. We have come to realize that the filter cloth is best designed when used as an auxiliary filter medium, so that we need no longer choose a filter cloth solely for its clarification properties. This fact alone is responsible for a considerable advance in the better discharge from many installations. No explanation is necessary as to the reason for this. It is apparent that dense cloths retain particles caught in its pores much more than thin or open weave cloths.

Open cloths have a further advantage in that they allow the reverse current of the discharging agent to exert a greater force in disengaging the cake from the filter medium than do dense cloths. The latter balloon out with the introduction of the discharging agent and prevent discharge of the solids—in fact, support the cakes and allow but little of the reverse air or steam to act upon the cakes.

The effectiveness of the discharge is often inaccurately indicated by an observation of the surface of the cloth. The rate of flow on the next cycle is the best proof of the thoroughness of the cleaning action. Some operators working on a granular material see the cake fall from the filter cloth the moment the pressure is released and see no need of further cleaning the cloths by reverse currents. To see those filters hung up while the leaves are taken out and hand scrubbed proves the utter inadequacy of the discharge. To leave only a minute film upon the cloth will in time necessitate strenuous methods in order to regain the original porosity. Thorough discharge is required at all times.

Reverse Current Discharge

Some of the most marked advances in filtration are due to the introduction of those continuous filters which employ reverse current discharge. Filters working on sodium carbonate, free-filtering calcium carbonate or gypsum may not require this means of discharge by reason of their extremely granular or free-filtering characteristics, but cement slurries, kaolin and other finely divided materials are inapplicable without this means of discharge. If some of this kind of material is left on the cloth, recurring filtration causes fine particles to wedge into the deposit and a scale-like, impenetrable mass results and most effectively blocks off further filtration.

The advantage in the use of compressed air, steam or water as the discharging agent is dependent upon local conditions. In leaf filters reverse current through the leaves while they are submerged is often more efficacious than the same current through the leaves suspended in the atmosphere. There is a good reason for this, for with the submerged leaves the water has an opportunity of getting underneath the cake and helps release the cake when the air current issues through the cloth.

Some operators are quick to condemn reverse current discharge because it will in some cases clear small areas on the leaves and leave the remainder undischarged. It is true that if the air can escape through a part of the cake it will not issue through the rest of the leaf forcibly enough to release the cake. Such conditions indicate, however, that either too dense a cloth is being used or else that there is some tenacious constituent in the cake which defies discharge. In this respect it is well to point out the analogy between the nap on the surface of a cotton or cellulose filter cloth and the hair used in plaster for wall and ceilings. Each has a binding action and the nap of the filter cloth is a big factor in causing ineffective discharge, so that metallic fabrics are often advantageous just for this point alone.

It cannot be too strongly emphasized that automatic

*For Parts I, II and III, see Chem. & Met. Eng., vol. 22, Nos. 22, 23 and 24, June 2, 9 and 16, 1920, pp. 1015, 1077 and 1119.

discharge from leaf type filters is due to the combination of the releasing the cake from the cloth and the fall of the material due to gravity. Therefore any impediment that blocks either factor jeopardizes the discharge. Some cakes have a relatively high tensile strength—are leathery in texture—so that the mere bridging over of the cake at the top of the leaves is sufficient to hold those cakes from discharging. In such cases it is good practice to coat over or cover the rim of the leaves and prevent filtration at this point so that no bridging effect is possible. The same is true of any obstruction which tends to hold the cake, such as bulky side aligning lugs in Sweetland filters, unflattened drainage pipes in leaf construction, etc. If, therefore, the reverse current of compressed air is ineffective in releasing the cake from the surface of the cloth, if the cake is of too small a bulk, or is prevented from falling by some obstruction, the discharge will be unsatisfactory.

Use of Air, Steam, Water or Scraper

Determining whether to use compressed air, steam or water, etc., as the agent for discharge, is a matter best decided in light of local conditions. Generally speaking, however, compressed air is the best. Its pressure is easily controlled, it adds no moisture to the discharge cake and its temperature has no deleterious effects on the filter cloth. It does, of course, have a cooling action and when handling hot liquor it may then be that steam can be substituted to better advantage. Steam has its good points, especially in that the cake, always being cooler than the steam, causes a slight condensation at the inner surface of the cake which often lubricates the surface of the filter cloth and facilitates discharge. Water or any liquid is in a sense the best reverse current because it more forcibly pushes the cake from the cloth, but its use is obviously limited. Unless the leaves are submerged, the water will often fail to remove the upper parts of the cake before it issues through the cloth at the bottom of the leaves and never issue through the upper areas.

When the cakes are thin and have not sufficient bulk to fall of their own weight, when released by the compressed air, discharge from leaf filters is impractical without submerging the leaves or without using scraping methods. If the latter must be resorted to, it must be realized that the scraper has the tendency to smear the cake into the pores of the cloth unless the reverse current of air is operating at the same time. This is the basic reason for the efficiency of discharge in continuous vacuum filters and in the automatic discharge plate and frame presses.

Thickness of Cake

Often thin cakes are held to be incapable of discharge by reverse current methods, whereas the trouble lies in the construction of the filter leaves. When the reverse current of compressed air is first turned into the leaves, the effect is to balloon out the filter bags, especially with dense cloths. When the bag is distended, the upper part of the bag supports the cakes from falling, even though the reverse air has efficiently disengaged the cake from the cloth. This is, obviously, a contrary condition for the best discharge of the cake. It is minimized by securing the cloth to the leaves at intervals across the entire area of each leaf or by lateral stitching of the cloths forming pockets into which wooden slat, etc., drainage members are inserted. Then the ballooning effect is decreased sufficiently that the discharge of the cake is just as efficient at the top of the leaf as at the bottom. In continuous vacuum filters the sections are narrow enough and the wire winding is spaced close enough that ballooning of the cloth gives no trouble with these machines.

Very thin cakes are difficult to discharge, but do not offer the difficulties encountered in discharging cakes that are too thick. In leaf filtration cakes are too thick only when adjacent cakes touch each other. Such a condition is diametrically opposite to the theory of operation in this type of filter. It is fundamental that a space remain between adjacent cakes that there may be room for the free fall of the cakes when released from the filter medium. When the entire space between leaves is filled with cake, it is rarely that the cakes can be discharged. Overcharging of a leaf filter is bad operation and indicative of poor control. If it were that the extra time required for discharge were its only disadvantage it would not be so necessary to emphasize this point. But overcharging is productive of warped leaves and they kill any hope of efficient filtration.

Filtrate and Cake Rating

Overcharging is due either to too long a filtering cycle or to too narrow spacing of the filter leaves. Either condition is easily controlled and good filter operation demands the prompt eradication of those conditions. There are liquors which as the precipitate is commonly formed contain too high a percentage of free-filtering material to be easily controlled in leaf type filters. Wherever possible, these materials should be handled in continuous type filters, which are more adaptable to this class of work, but where temperature, acid content, etc., call for leaf filters, the widest practical spacing should be employed, and if the solids still build too freely, then the liquid content of the material should be increased by returning some of the filtrate.

Consideration of overcharging brings out the point too often overlooked, namely, that the rating or duty of a filter can be either in terms of filtrate delivered or in cake built up. With very free-filtering materials the latter view is the safer, and while it must be measured by the quantity of filtrate delivered or by the time of filtering, it is the prime consideration, for seldom is the economical limit of filtration for such materials reached by waiting for the filtrate to decrease in flow to its economical limit. To do so would build up a cake too voluminous and heavy for the best operation both as regards washing and discharging. In design Sweetland type filters are admirably adapted for those solids which easily fall from the leaves, for the lower half of the machine opens away from the leaves which do not have to move the cakes. In practice, however, the cake in the lower half is often a load in excess of the power of the operating cylinder and makes for dangerous banging of the counter-weights against the shell. Also, the cake remaining in the lower half has to be removed by hoeing it out by hand or hosing it out with water.

When filters are working on liquors containing a small percentage of solids they are better known as clarifiers. In this class of work the solids build up to form only a thin coating on the cloth and a discharge by reverse current methods in leaf filters or any discharge in continuous filters is impracticable. The customary method is to sluice the solids off the filter cloth by forcibly spraying water on the surface of the cloth. This is

efficient when the solids have not penetrated the pores of the cloth. Success of such methods is evidenced by the record of the Merrill plate and frame presses in the cyanide industry and Sweetland filters in cane sugar refineries. In both of these filters the sluicing is done by rocking the sluicing pipe or manifold back and forth so as to project the sluicing streams over the entire surface of the cloth. This operation is invariably done without opening the filter and in respect to cleanliness of operation is distinctly advantageous.

Pre-Coating Aids Discharge

With most materials that are handled in clarifiers and which tend to clog the pores of the filter medium it is indispensable to build up an auxiliary filter medium upon the cloth before commencing the clarifying operation. This medium has been described in the article on Clarification as a "pre-coat," and inasmuch as the pre-coat is easily sluiced from the cloth its advantages are obvious. In sluicing discharge there are two points which must not be overlooked. The sluicing streams must be directed to the cloth with sufficient force to remove the solids and the water must not be allowed to collect in the filter so as to submerge a part of the leaves. Both points should be covered in the design of the machine, but where an ordinary filter is being used as a clarifier the nozzles must be spaced and aligned correctly with the limits of the lateral travel fixed. The drainage at the bottom should be unrestricted and if necessary two drainage openings should be used.

The discharge from gravity tank filters has usually been by the laborious methods of hand shoveling. It is simple, however, to rig up automatic means, especially if wet discharge is not objectionable. All that is required is a drainage opening and to forcibly eject the cake with a water hose. It is also possible to discharge the solids mechanically by using a rotating raking device that can be lifted free of the liquor level while filtration and washing take place and that can be lowered into the cake when ready for discharging. The weight of the rakes will be fed sufficient to plow into the solids. The rakes must, of course, be designed to move the mud toward the outlet provided in the tank.

TABLE I.

Time	Elapsed Time	Interval in Min.	Flow in Gal.	Increment in Gal.	Pres. Lb. Sq. In.	Temp. Deg. Fahr.	Dens. Deg. Be.	Remarks
9:00	0	0	0.0	0.0	0	0	0	Filling
9:05	0	0	0.0	0.0	0	0	0	Filtering
9:08	3	3	15.0	15.0	10	182	32	Clear
9:10	5	2	25.0	10.0	12	182	32	
9:15	10	5	46.0	21.0	16	181.5	32	
9:20	15	5	63.5	17.5	20	181	32	
9:22	17	2	71.0	7.5	22	181	32	Pump stopped
10:27	17	0	71.0	0.0	0	...	..	Pump repaired
10:30	20	3	78.0	7.0	25	179	32	
10:35	25	5	90.0	12.0	25	179	32	
10:40	30	5	100.25	10.25	25	178	32	
10:45	35	5	108.75	8.5	25	178	32	
10:50	40	5	114.75	6.0	25	177	32	
10:55	45	5	119.25	4.5	25	177	32	
11:00	50	5	123.25	4.0	25	176	32	
11:05	55	5	127.0	3.75	25	176	32	Filtered
11:10	0	0	0.0	0.0	10	...	..	Washing
11:15	5	5	6.0	6.0	30	176	32	
11:18	8	3	10.5	4.5	30	177	30.5	
11:20	10	2	13.5	3.0	30	177	31	
11:22	10	2	18.0	3.5	30	178	29	
11:24	12	2	20.5	4.5	30	179	22	
11:26	14	2	28.5	6.0	30	180	8	
11:28	16	2	36.5	8.0	30	180	3	
11:30	18	2	45.0	8.5	30	181	0.5	
11:32	20	2	54.0	9.0	30	182	0	Stop
11:34	0	0	0.0	0.0	10	...	..	Drying
11:37	3	3	10.0	10.0	28	...	..	Dried
11:47	10	..	.....	.....	..	...	..	Discharged

COMPUTATIONS

Tare:
- 5 minutes filling.
- 5 minutes draining excess and filling with wash water.
- 20 minutes washing.
- 2 minutes draining excess water.
- 3 minutes drying.
- 10 minutes discharging.

45 minutes.

Points on curve:
- 45 minutes tare.
- 5 minutes filtering.

50 minutes cycle; 25 gal. flow divided by 50 minutes equals 0.5 gal. per minute.

- 45 minutes tare.
- 40 minutes filtering.

85 minutes cycle; 114.75 gallons flow divided by 85 minutes equals 1.35 gallons per minute.

The Economy Curve

One of the most illuminating graphs arising from modern filtration developments is that known as the economy curve. Engineers will be struck with the similarity of this with that of the conventional "characteristic" curve of centrifugal pumps. The point of flexure is in both cases the economical limit. In the filtration curve it marks the limit of economical filtering cycle more positively than any other curve. While in practice the amount of liquor handled per shift may be said to be an infallible proof of the best working of the filters, the experimenter has this means of predicting that cycle productive of maximum capacity and it is more for his benefit that the curve is insisted upon in good laboratories.

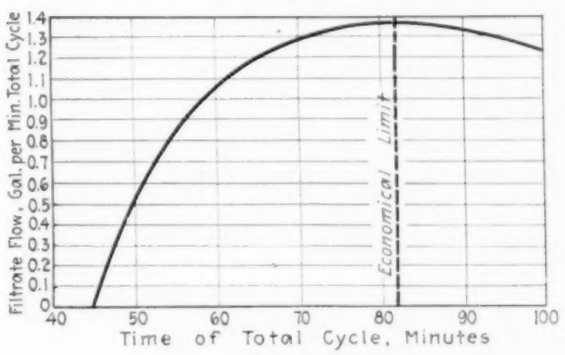


FIG. 7. ECONOMY CURVE

The points on the curve are computations of the rate of flow per minute for each cycle when it is assumed that the tare of the cycle remains constant and that each successive point on the curve is the flow for the cycle if the filtering cycle had ended at that period. The assumption that the tare is constant is based on the fact that the time of filling the filter preparatory to filtering the liquor is a constant, that the time of withdrawing the excess unfiltered liquor and admitting the wash water is almost constant irrespective of the amount of cake deposited, that the withdrawal of the excess wash water takes practically the same time for varying filtering cycles and that the drying, discharging operations and closing up the filter again are practically constants. The time of washing the cakes is a variable with widely differing amounts of cake deposited, but in practice the variation in the length of the washing period is small and for the purpose of this curve can be taken as a constant.

Table I is the form in which it is found most convenient to record the date of a test and from it is computed the points outlining the accompanying curve.

(Part V, General Discussion and Auxiliaries, will be published in a subsequent issue.)

The Potentiometer in Pyrometry

By Charles P. Frey*

DR. GEORGE SIMON OHM published what was originally called "a remarkable mathematical theory" in 1827, and aroused a storm of discussion. It was not until about 1841, when the Copley Medal was awarded to him by the Royal Society of England, that his "theory" was accepted as an axiom, and the importance of his contribution to science fully recognized. Ever since, physicists have labored to establish fundamental units of resistance, current and voltage, and to secure their general adoption.

Fundamental Units

Necessarily, the unit of resistance had to be based upon the physical characteristics of materials; and after much experimenting and discussion the resistance of a column of mercury 106.3 cm. long and 14.4521 g. in mass, having a constant sectional area at 0 deg. C., was adopted and appropriately called the international ohm.

It remains a matter of controversy whether the volt or the ampere can be more easily determined. Since absolute measurements are impossible, the deposition of silver was advocated by many as a medium for current determinations, and the ampere is defined as that current which will deposit 0.001118 g. of silver per second. The electromotive force which will produce such a current, when applied to a conductor having one international ohm resistance, must necessarily be one volt.

The volt, or unit of electromotive force, can now be established with great accuracy by the proper construc-

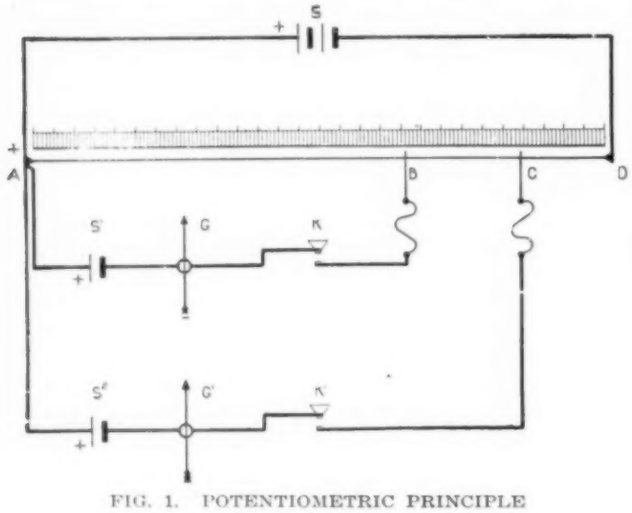


FIG. 1. POTENTIOMETRIC PRINCIPLE

tion of cadmium sulphate cells. The ohm can also be produced in practical form by the substitution of the alloy manganin for mercury.

The Potentiometer

By means of a potentiometer, comparisons of emf. can be made with extraordinary precision. The principle of the potentiometer may be demonstrated as follows, referring to Fig. 1:

A constant current flows from battery S through a resistor $ABCD$, of uniform cross-section. A potential difference is therefore established between the extremes, and between any two points from A to D.

If S' is a cell, the known emf. of which is less than that of S, a balance may be obtained when the contactor B connects at a point on the wire found by trial. At that time no current flows through the galvanometer G, with the circuit closed by means of key K. When this is the case, the potential between A and B will be equal to the emf. of the cell S'. The emf. of the cell S'' may then be compared with the emf. of S' by moving C, and when balanced, $S'' : S' :: AC : AB$, in terms of the emf. of S'.

The significant feature of this test is the number of unknown values permissible. The current through the

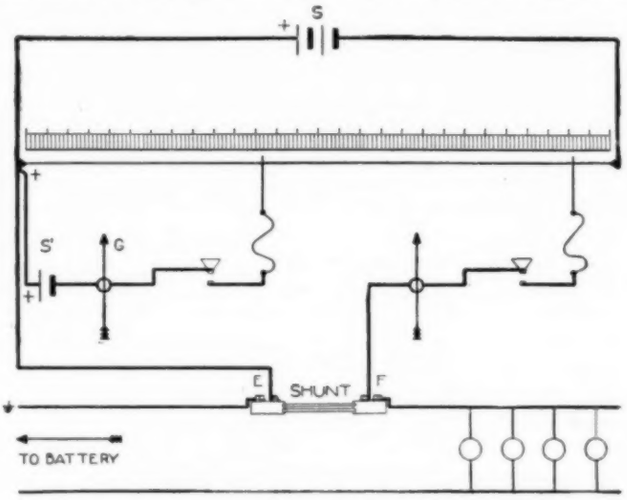


FIG. 2. CURRENT MEASUREMENT BY POTENTIOMETRIC METHOD

feeder circuit including AD, the emf. of S, the resistance of the slide wire and the sensitivity of the galvanometers may all be ignored.

All potentiometers, even the most elaborate and intricate, embody the above principle and depend upon a balance between a known potential and a potential which may be indeterminate. The potentiometer in practical form usually has a calibrated scale which permits direct readings of voltage, or in pyrometry, of temperature equivalents; and by the introduction of proper switches only one galvanometer is required.

In all exact quantitative potentiometer measurements it is necessary that the known emf. has been determined with the utmost exactness and that it is not subject to variations. It is also requisite that the galvanometer is sufficiently sensitive so that when its needle becomes stationary a balance of forces has actually been established.

Current Determinations

The potentiometer may also be used for the measurement of current with great accuracy by the "fall of potential" method or "drop" across the terminals of a shunt.

For instance, if the resistance of the shunt in Fig. 2 is known, the current is determined by finding the drop across EF. This method is necessarily in the nature of laboratory testing and is not direct reading.

By the substitution of a deflecting millivoltmeter in place of the potentiometer, direct indications may be obtained in current measurements, as shown in Fig. 3.

The millivoltmeter scale may be calibrated to indicate amperes, since the current through its movable coil must necessarily be a definite part of the total current undergoing measurement. In this test, the millivoltmeter indications will be a direct index of the drop

*Chief Engineer, the Brown Instrument Co.

across P-P^1, provided the instrument resistance is sufficiently high not to materially reduce the circuit resistance, as a whole, by its own conductivity.

The Movable Coil Galvanometer

Nearly all direct current ammeters, as well as voltmeters, millivoltmeters, galvanometers and pyrometers operating on the movable coil principle, are based on the original investigations of Ampere in 1820.* And it is appropriate to state that all measurements depending upon galvanometers are essentially *current* measurements, although scale readings may be interpreted in volt, ohm, temperature or resistance equivalents.

The degree of accuracy attainable with a deflection galvanometer depends upon the extent of the deflection, also upon the permanence of the magnetic field and the constancy of the controlling forces, such as gravity and the retarding torque of metallic conducting springs or suspension fibers. The temperature coefficients of the conductors are also factors, but errors from such sources can be practically eliminated by the use of properly proportioned materials.

Substitution Checks

In the employment of any measurement apparatus, confidence in the accuracy of its indications is necessary if practical results are desired. Yet if doubt exists, there is always one comparatively easy method by which a check can be made, which is by substitution. Standard weights can be interchanged, thermometers can be read while subjected to the same temperature, two or more millivoltmeters can be connected in multiple, shunts can be checked in series and standard cells can be tested by the opposition method or by replacement.

Potentiometers for Pyrometry

In the selection of a potentiometer best adapted to the requirements of pyrometry, consideration should be given to the fact that since it cannot be adjusted and then read as quickly as the indications of a deflection instrument can be observed, there remains only one reason for its employment, which is on the score of greater accuracy. It also should be designed to be convenient for the measurement of emf.'s which are almost

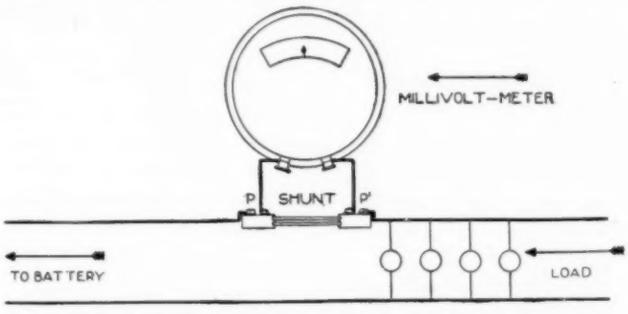


FIG. 3. MILLIVOLTMETER ACTING AS AMMETER

invariably less than 0.05 volt, and have a scale which is not only extremely accurate in its calibration, but which in addition is long enough, or as it is called, sufficiently "open," to permit small differences in potential to be determined with rapidity and precision. If, for instance, such a scale has a length of only about 10 in., and is calibrated to have a range of 0 to 50 millivolts, one millivolt will have a scale length of about 5 mm., or $\frac{1}{5}$ of an inch. Therefore, even if such an instrument is used for measurements near the upper end of the scale and it is possible to read by interpolation to $\frac{1}{10}$ scale division, the extreme limit of accuracy, with no allowance for what is called the personal equation, or error in observation, will be $\frac{1}{2}$ of 1 per cent.

Taking into consideration the fact that a platinum platinum-rhodium standard couple develops only 5.95

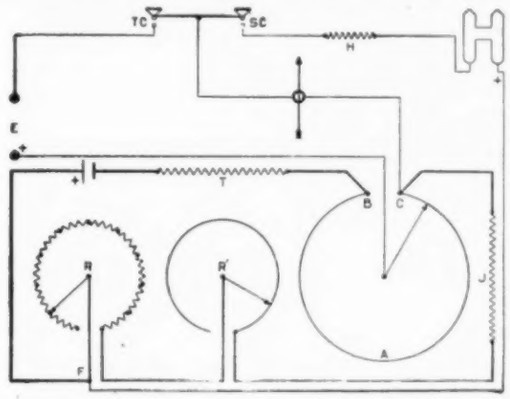


FIG. 4. PORTABLE POTENTIOMETER CIRCUITS

millivolts at a temperature of 1,200 deg. F., it is evident that such an emf. cannot be read with extreme accuracy on a scale which is too short to be sufficiently subdivided.

The scale in the newly developed Brown potentiometer overcomes this objection, since it is 7 ft. 10 in. in length, inscribed spirally upon a drum. The drum wire is wound upon a corresponding insulated cylinder mounted on the same axle and rotating with the scale drum.

The fundamental principle of this instrument may be readily understood by reference to Fig. 4, which illustrates the scheme of an ordinary portable potentiometer. A constant current from the plus side of a small dry cell flows continuously through the rheostats R and R^1, the ballast coil J, the slide wire CAB, and the resistor T, back to the cell. The current through this circuit is regulated by means of the rheostats R and R^1 so that the emf. between C and F will equal the emf. of a selected standard cell. When this is the case the potential drop of the slide wire CAB will have a predetermined value in millivolts between its extremes.

By connecting a source of current at E, its emf. can be determined by balancing it against a suitable part of the emf. of the slide wire. When these cylinders are rotated by means of a knob, an index moves across the scale. The motion of this index is synchronized so that the position of a contactor on the slide wire coincides with a corresponding position of the scale index.

The Standard Cell

Since the accuracy of these potentiometers depends directly upon the emf. of the standard cell, great care has been given to secure satisfactory ones. They conform with the recommendations of the Bureau of Standards and are of the type known as unsaturated.

The Weston normal cell, invented by Edward Weston, containing a saturated solution of cadmium sulphate, was adopted by the Bureau of Standards in 1911 as the standard of emf.; $E = 1.01830$ international volts at 20 deg. C. Saturated cells, if extreme precautions are adopted in their construction, can be produced from different materials and agree within a few parts in 100,000, but owing to the fact that they have a small

*See "The Galvanometer," by E. F. Northrup, CHEM. & MET. ENG., vol. [illegible], p. 944.

temperature coefficient (approximately —0.00004 per deg. C.) they are not preferable for practical measurements, independent of temperature variations.

Another cell, also the invention of Dr. Weston, is identical with the normal standard in ingredients except that the solution used is diluted instead of being saturated. The effect of this dilution is to slightly increase the emf. and to reduce the temperature coefficient to practically zero (—0.00001 per deg. C.). The exact emf. of a properly "aged" cell of this type should lie between 1.0184 and 1.0190 volts, and its voltage will remain constant within 0.01 per cent for years, provided the cell is not short-circuited or otherwise abused.

Since in unsaturated cells the density of the solution affects the emf., this gives manufacturers of precision instruments the advantage of employing cells which are alike in emf. and which may be therefore interchanged. A further advantage lies in the fact that the constant emf. of these cells simplifies the construction of potentiometers, since it obviates the necessity of introducing a thermometer and a device to "set" the instrument to correspond with a definite voltage at a known temperature, which is necessary for precision tests if the usual standard cell is used.

The cell in the Brown potentiometer is packed in a portable case which includes a resistor of about 3,000 ohms, to prevent damage in case of accidental short-circuit. This case can be speedily removed if it is considered desirable to have the cell standardized. Meanwhile, a duplicate cell may be substituted, whose case interchanges with the original, so that only two connecting leads need be secured to binding posts.

A small dry cell is used to furnish current for the main circuit. This cell is called "705 Eveready," and can be purchased in any electrical supply store.

Current Requirements

Nearly all portable potentiometers have a drum wire of low resistance measuring about 20 ohms. Consequently, to obtain sufficient "drop" or potential difference between its extremes, a comparatively large current is necessary. Therefore, the dry cell which furnished this current is constantly falling off in emf., due to polarization, and by use is rapidly exhausted. Furthermore, the current does not remain steady for any length of time and the rheostat requires constant resetting to keep the instrument in balance.

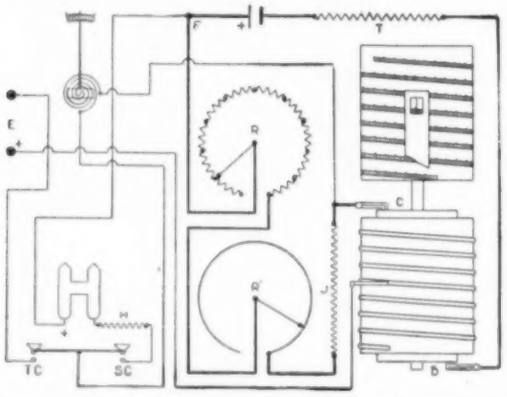


FIG. 5. DIAGRAM OF BROWN POTENTIOMETER

In this new potentiometer (Fig. 5), the drum wire has a resistance of 140 to 150 ohms, and the total instrument resistance for 50 millivolts is approximately 4,175 ohms, including the resistance of the rheostats. This is gradually reduced, by regulating the rheostats, to a minimum of about 3,400 ohms, when the dry cell is exhausted and must be renewed. The emf. of the dry cell is from 1.5 to 1.2 volts, according to its condition, and the current required to operate the potentiometer is never more than 0.00036 amp. or about one-tenth the current required to operate potentiometers of the ordinary portable type. The result is that the dry cell will have a long life (from three to six months, according to condition), which is of course an advantage; but what is of far greater importance is the fact that the current drawn from the dry cell is so small that the cell will not polarize and will give a practically constant current, subject only to temperature changes. Consequently the potentiometer, after being balanced against the standard cell, will remain in balance for hours without readjustment. Hence a large number of tests can be made in succession with the absolute certainty that there will be no errors introduced due to change in the potentiometer current.

Galvanometer

In the construction of any instrument in which the opposition or "zero" method is employed, a sensitive galvanometer is indispensable, in order that it will respond to minute changes in current. The galvanometer has no suspension fibers and the movable coil does not turn with an erratic motion, dance or vibrate. It is positive in its indications as well as aperiodic in action. Its resistance is approximately 150 ohms.

Sensitivity

If an electromotive force of one volt is impressed on a resistor of one megohm (1,000,000 ohms) the flow of current will be one-millionth ampere, or one microampere. This current, when passed through the movable system of the Brown portable galvanometer, will cause a deflection of 2.8 mm. Stated differently, the galvanometer has a guaranteed sensitivity of 2.8 megohms (10^{-6} amp.). These remarkable results are obtained by using tungsten alloy magnets, a concentrated field and a movable system wound with special enamel-insulated aluminum wire. The weight of this movable system is so slight that it is unaffected by mechanical jars in transportation, the pivots remaining sharp under all conditions, with no reduction in sensitivity.

Automatic Compensation, Single Scale

A single scale potentiometer intended exclusively for a certain type of thermocouple is calibrated in temperature degrees, either Centigrade or Fahrenheit or both, and may be automatically compensated for temperature changes in the cold ends of the couple. But such an instrument can be used only in connection with the type of thermocouple for which it has been adjusted and cailbrated.

Philadelphia, Pa.

Vegetable Oil for Italy

Recent inquiries have been coming to Japan for vegetable oil, due to decrease of imports from Holland, and some contracts for export to Italy have already been consummated. A considerable quantity of vegetable oil was shipped by the N. Y. Y. steamer Wakasa Maru, which sailed for Genoa with the Japanese shipping delegates on board. It is said that the N. Y. Y. contemplates in case of regular shipment of oil to Italy, sending its ships to Genoa.

Chart of Viscosities in Different Systems

By H. G. Nevitt

VISCOSITY is variously defined as the degree of fluidity of a liquid, its internal friction or shearing modulus. This property is an important one in many liquids, and the primary one in a lubricant, as it is the most important indication of its fitness for that purpose. Viscosity is commonly measured by an instrument which allows the liquid to flow through an orifice, the degree of viscosity being given by the time taken by a fixed quantity of liquid to flow through.

Obviously in the case of any viscosimeter, where the time of flow or similar direct reading is taken, the viscosity factor is a function of the instrument as well as the liquid. Attempts to get away from this have been made by getting a comparative viscosity, as in the Engler method, where the ratio of the time of flow of the liquid to that of water is taken, or by obtaining the actual shearing force, or absolute viscosity, which is a function of the liquid only.

At the present time there are a number of instruments and systems used, but the following are the most common:

The Saybolt Universal, or time on Saybolt instrument.

The Redwood, or time on the Redwood instrument.

The Engler number or comparative time of flow, with water equal to unity.

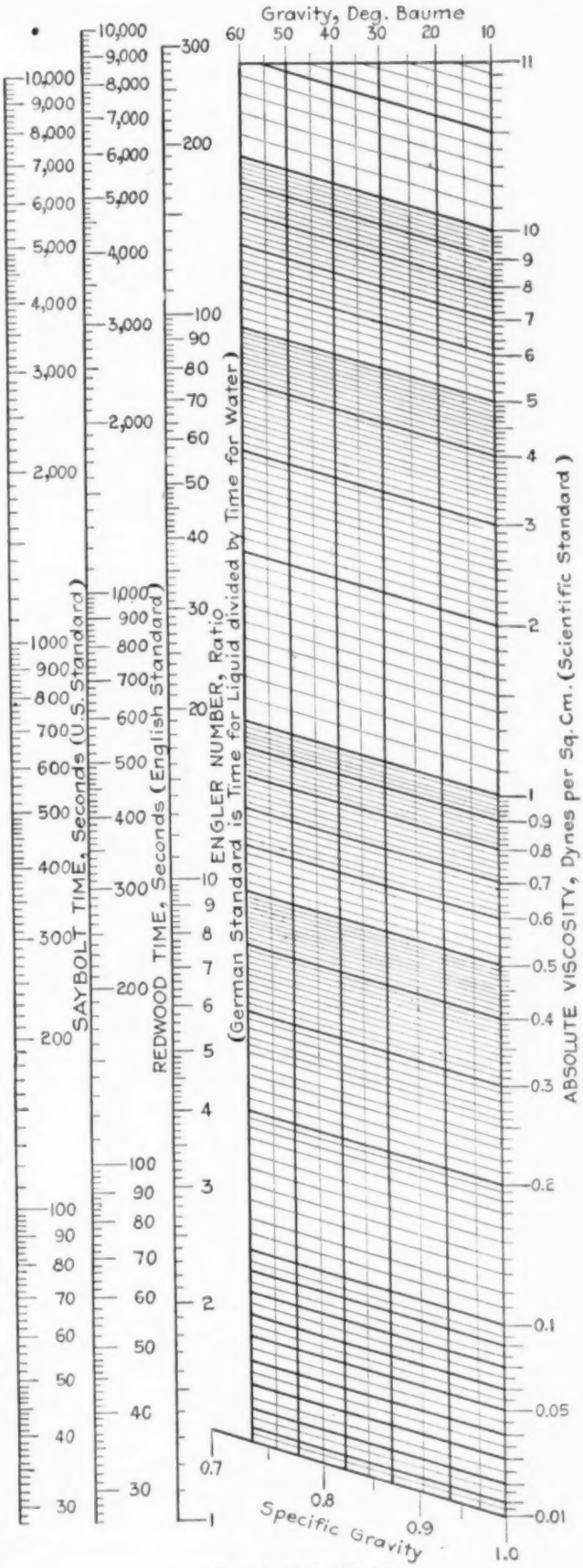
The Absolute Viscosity in c.g.s. units. This involves the specific gravity as well as the time of flow on an instrument, as two liquids of the same time of flow but of different densities have different internal shearing resistances. However, as most liquids being compared generally have about the same specific gravity, this does not cause trouble.

The confusion that may result from the number of systems in use is apparent. This is especially true of the export trade, and when dealing with foreign authorities and data on liquids. In the petroleum industry especially, where viscosity is an important and controlling factor in handling some of the distillation fractions, the difficulties of knowing more than one system or changing over become considerable, if a large number of distillations are being compared. In consequence we are almost forced to some quick method of comparison, and the graphical seems by far superior.

To do this the common method of plotting the various values reduced to equivalent scales, so the value in any other system is read opposite the quantity on the given system, is used. The correction for the specific gravity in reducing to the absolute system also presents no difficulties graphically.

Any basic scale of laying off the values on the primary system may be chosen, but the logarithmic seems best for several reasons. It covers a wide range of viscosities without too small a scale for reading in the common range of values. It also makes the most probable error of reading constant in percentage, rather than in amount. This is also an advantage in that the error of determination is also approximately constant in percentage, so that inconsistencies in reading the chart are avoided. By then plotting the co-ordinate lines for specific gravity to a logarithmic scale also, the lines for variation of absolute viscosity with specific gravity become straight and have a constant slope.

Tampico, Mexico.



VISCOSITY CHART

To obtain equivalent viscosities, read horizontally across the scales. A sheet of paper cut square makes an excellent guide. Example:

An oil of 30 deg. Bé. gravity has a viscosity of 200 on a Saybolt instrument. Read Redwood equivalent as 168; Engler as 5.34 and absolute as 0.328 from the chart, using the 30 deg. Bé. line for the absolute intersection.

The German Works Councils Act

A RECENT issue of the British official *Labor Gazette* contains the following résumé regarding the provisions of the German works councils act:

A works council act (Betriebsrätegesetz) was passed on Jan. 18, 1920, in order to guarantee the general economic interest of workers (manual and non-manual) in relation to their employers and to assist the employers in carrying out the aims of their undertakings.

The term "worker" (Arbeitnehmer) covers all manual and non-manual workers with the exception of members of the employer's family. It does not include persons whose employment is not mainly for profit.

Works councils must be set up in all establishments employing as a rule at least twenty workers. In smaller establishments a works steward must be elected. A special works council for outworkers must be set up when twenty or more are employed. In order to guarantee special economic and social interests, separate councils for manual and non-manual workers must be set up wherever both classes are represented on the works councils.

Council Members Elected by Secret Ballot

Members of the councils are to be elected by direct and secret ballot according to the principles of proportional representation for the year; they shall be eligible for re-election. All workers, male and female, of eighteen years and over, in possession of civil rights have the right to vote. All with the right to vote who are twenty-four years of age and over, who are not learners and who have been at least six months with their employer and three years in the industry, are qualified for election.

Rules are laid down for election procedure, and the Federal Minister of Labor, in agreement with the Federal Council and a committee of the Reichstag consisting of twenty-eight members, is empowered to issue administrative regulations.

If a works council has nine or more members it must elect from its own members a works committee of five persons.

Provision is made for (1) a central works council in addition to, or (2) a joint works council instead of individual works councils when interdependent establishments are owned by the same firms, etc.

Functions of Works Councils

In section 66 it is laid down that it shall be the function of the works council to help the management to secure efficiency; to protect it from unauthorized interference, and, failing agreement in disputes, to appeal to the conciliation committee or to an arbitration board to be agreed on; to fix or modify, in agreement with the employer, the conditions of service; to promote a good understanding between workers and employer and to maintain the workers' right of forming associations to take measures to prevent danger to health and accidents; and to co-operate in the administration of pensions, housing, or other welfare schemes attached to the establishment.

The works council has the right to require the employer to give to the works committee information as to all the transactions of the establishment which affect the contract of service and the activity of the workers (provided no business secrets are endangered or legal regulations contravened), and to show the wages, books, and give other information necessary for carrying out existing collective agreements. The employer must supply a quarterly report on the position and progress of the undertaking and of the industry in general, as well as of the output of the establishment and the expected demand for labor.

Penalties of the Act

Any person who with intent to deceive the workers shall give wrong data or conceal correct data in reports on the financial position is liable to imprisonment not exceeding one year and to a fine not exceeding 10,000 marks, or to either of those penalties. Any person disclosing confidential information given to him as a member of a works representative body is liable to a fine of not more than 1,500 marks or to imprisonment; if convicted of intention to gain financial advantage or to injure the employer, heavier penalties may be imposed.

Should the engagement or dismissal of a considerable number of workers become necessary, the employer must as soon as possible discuss with the works committee or the works council the nature and extent of the necessary changes and the possibility of avoiding hardships.

The functions of the manual and non-manual workers' councils are of a more specialized character. They include, among many others, the laying down of guiding rules for the engagement of workers in their group in the establishments and co-operation in carrying out the regulations as to their discharge.

The engagement of a worker must not be conditional on his political, military, religious, or trade-union views, or on his belonging or not belonging to a political, religious, or occupational union or to a military association. The rules must not prescribe that the engagement shall depend on belonging to a particular nationality.

Appeals Against Discharges

Provision is made for appeal by the councils against the engagement or discharge of workers to the competent conciliation committee or an arbitration board. Discharge without a statement of the reason for it is one of the grounds of appeal.

If the appeal against dismissal is held to be valid, the employer must either offer reinstatement or give compensation for dismissal. The amount of compensation is fixed at the rate of one-twelth of the earnings in the last year for each year of service, but should not in all exceed six-twelfths. Should the worker accept reinstatement, the employer must pay him his wage or salary for the period between dismissal and reinstatement. Should the worker refuse re-employment he is entitled only to wage or salary for the period between the date of his discharge and the date of the conciliation committee's award.

Before giving notice of dismissal to a member of a works representative body, or before transfer of such a worker to another establishment, the employer must obtain the consent of the works representative body.

Membership List of American Chamber of Commerce in Mexico

A printed list of the members of the American Chamber of Commerce of Mexico City has been issued and can no doubt be obtained on application, addressing American Chamber of Commerce of Mexico, at 2A Motolinia 23, Mexico City, Mexico.

Use of Paranitraniline to Standardize Solutions of Sodium Nitrite

By William H. Bell*

THE usual method for the analysis of aromatic amines, such as anthranilic acid, amino G salt, benzidine, dimethylparaphenylenediamine, etc., consists in the diazotization of a definite amount of the aromatic amine by means of a standard solution of sodium nitrite, the end point being ascertained by means of starch-iodide paper. The usual procedure is to use an M/1 (M = molecular weight in grams per liter) solution of sodium nitrite, which is allowed to fall, drop by drop, into a hydrochloric acid solution of the amine. It is customary to dilute the amino solution to about 500 c.c., and to maintain it at a temperature of approximately 15 deg. C., but these factors vary with each individual compound. In some cases, such as aromatic amines containing sulphonic or phenol groups, the amine is first thrown into the sodium salt, the solution cooled, and while stirring vigorously, the compound is precipitated by means of hydrochloric acid. Since the particles come out of solution in fine condition, diazotization is greatly facilitated. Again, in other cases, it is necessary to heat the amino compound with hydrochloric acid, in order to secure solution.

Another factor which varies considerably is the temperature—some compounds must be diazotized as low as 5 deg. C., while others may be safely diazotized as high as 40 deg. C.

In every case, however, the solution is constantly stirred by means of an automatic stirrer, and the sodium nitrite is allowed to drop at such a rate that is used up very quickly. The latter is, of course, ascertained by removing a drop of the solution and testing it with starch-iodide paper.

The Lunge Method

The ordinary procedure in use for the analysis of aqueous solutions of sodium nitrite is based upon the method of Lunge. His method consists in adding a definite volume of sodium nitrite solution to an excess of $KMnO_4$ solution, which has been acidified with sulphuric acid. Sufficient time is allowed for all the nitrite to be oxidized to nitrate, then an excess of KI solution is added. Iodine is liberated and the latter is titrated with sodium thiosulphate, starch being added as indicator.

There is no question as to the accuracy of Lunge's method. However, in the diazotization of aromatic amines, there is a constant source of error, due to the fact that free nitrous acid must be present before an end point is reached. Furthermore, if the sodium nitrite solution had been standardized against an aromatic amine of definite purity, the end point in standardization would contain the same error as is met in the diazotization of unknowns, and the two sources of error, being practically the same, would tend to neutralize each other. The chief source of trouble in applying this method has been in securing an aromatic amine of definite purity. Paranitraniline serves excellently for this purpose, since it can easily be secured in pure form as long yellow needles, of correct melting point, and which I have found by a number of methods to analyze 100 per cent.

Paranitraniline Method

In standardizing an M/1 solution of sodium nitrite, the following procedure is recommended: Dissolve 70 g. of sodium nitrite per liter of distilled water. This will give approximately an M/1 solution. Weigh out 3.4517 g. of paranitraniline, wash into a 600-c.c. beaker, add 10 c.c. conc. HCl, and 100 c.c. water. Heat to effect solution, then add ice and water until temperature is approximately 15 deg. C., and volume of liquid about 350 c.c. Start automatic stirrer, and add sodium nitrite solution, drop by drop, from a burette. If solution is exactly M/1, just 25.0 c.c. of $NaNO_2$ will be required. When 22 or 23 c.c. of solution has been used, it is necessary to test the solution very often for excess nitrous acid. It is best to do this by removing one drop by means of a glass rod and applying it to a piece of starch-iodide paper. When excess nitrous acid is indicated, shut off burette, and test frequently again for several minutes in order to be sure that permanent end point has been reached. Run two other samples of paranitraniline in the same manner, and use the average of the last two results.

$$\frac{25.0}{\textit{No. of c.c. } NaNO_2 \textit{ used}} = \textit{Cor. Fac. for } M/1 \textit{ Solution.}$$

This method has been tested quite thoroughly and has been found quite accurate for the purpose. It is quicker and more convenient than Lunge's method.

Washington, D. C.

*Baldwin Fellow, University of Cincinnati; formerly Chemist, the Ault & Wiborg Co.

Peanuts and Peanut Oil Exports From China

Large quantities of peanuts and peanut oil are produced in the province of Shantung, China, and shipped abroad and to other parts of China. Customs returns show the exportation of the following from Chefoo and Tsingtao to foreign countries and various parts of China:

CHEFOO PRODUCTION IN PICULS

	1914	1915	1916	1917	1918
Peanuts	170,757	243,692	143,557	126,729	78,219
Peanut oil	98	6,834	3,692	2,102	5,326

TSINGTAO PRODUCTION IN PICULS

	Unshelled Peanuts	Shelled Peanuts
1909	336,635	214,000
1910	668,991	
1911	797,058	109,858
1912	829,419	230,987
1913	1,044,000	147,103
1914	964,676	75,573
1915	101,986	57,903
1916	533,601	234,541
1917	410,869	248,387

During the European war, higher freight rates and scarcity of ships caused a decrease in acreage devoted to the cultivation of peanuts, with a corresponding shortage in production and falling off of exports. With the restoration of peace, however, exports have been increasing.

The prices of peanuts and peanut oil are subject to considerable fluctuation. In the spring of 1913, peanuts were quoted at $8.70 (Mexican) per picul at Tsingtao, but just prior to the outbreak of war in 1914 the price fluctuated between $5.50 and $8. At present, however, the price is fluctuating between $4.80 and $9.80.

Peanut oil was quoted at $9.90 per picul at Tsingtao in 1914, but it rose to $19.50 in January, 1918, owing to the keen demand for the oil.

Peanuts and peanut oil are produced in all parts of China, but peanuts produced in Shantung province are well known for their superior quality and are in active demand in both Europe and America.

Recent Chemical & Metallurgical Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Indigo and Vegetable Extract Dye Compound.—Indigo paste combines with about eight times its weight of freshly prepared vegetable extract (such as logwood, quebracho or cutch) to form a compound which is readily soluble in soap solution or alizarine oil. This solution dyes yarn or cloth a reddish brown which is developed to the characteristic indigo blue by after-treatment with iron, copper or nickel salts, preferably a solution of copper oxide in ammonium carbonate. Unlike ordinary reduced indigo liquor, the blue color does not develop upon exposure to the atmosphere. JOHN W. FRIES, of Winston-Salem, N. C., has found that oxidized vegetable extract may be reduced by yeast fermentation so that it yields as good results as the freshly prepared extract. The compound may be marketed in powder or paste form. For use it is simply dissolved in 1 per cent soap solution. (1,341,637; June 1, 1920.)

Detonating Fuse.—Detonating fuse or cordeau is ordinarily made by filling a metallic (usually lead) pipe of, say, 1½ in. diameter with molten trinitrotoluene. When the TNT has solidified the diameter of the pipe is reduced by passing through a series of rolls. TNT makes the most satisfactory cordeau, but unless the TNT is very pure, the cordeau deteriorates with age. WILLARD C. COPE, of Woodbury, N. J., has found that the addition of tetryl (2.4.6-trinitrophenyl-methyl-nitramine) increases the velocity of detonation of the cordeau and also prevents deterioration so that an inferior grade of TNT may be used. The proportion of tetryl may vary from 2 to 75 per cent. (1,341,705; assigned to E. I. du Pont de Nemours & Co.; June 1, 1920.)

Caustic Mixtures.—Owing to the necessity of shipping caustic soda in airtight iron drums, JOHN ARMSTRONG, of London, England, proposes to ship a mixture of dry slaked lime and sodium carbonate, which will give a solution of sodium hydroxide when stirred with water, calcium carbonate being precipitated. The mixture is permanent in reasonably dry air and may be put up in paper containers. (1,342,148; one-half assigned to Patent Corporation, Ltd., of Liverpool; June 1, 1920.)

Sulphuric Acid Chambers of Acid-Proof Masonry.—The reactions in sulphuric acid chambers generate large amounts of heat which in lead chambers must be dissipated by radiation. Since the radiating capacity of the chamber is practically a fixed quantity, a rather definite limit of production is set beyond which the chambers fail to function properly. It has long been recognized that the reaction velocity in the chamber process could be increased by a vigorous mixing of the gases, causing them to impinge upon surfaces wet with acid. However, forms of construction hitherto proposed have involved the use of lead so that increased construction and maintenance costs overbalanced the advantages due to increased reaction velocity. ELDON L. LARISON, of Anaconda, Mont., constructs the chamber of acid-proof masonry. The heat of reaction is removed by continuous circulation of sulphuric acid over the tower packing. The concentration of the acid is so regulated as to avoid the absorption of material quantities of nitrogen compounds. By employing for every 2 lb. S in the form of SO_2 an amount of nitrogen compound equivalent to from 1 to 2 lb. $NaNO_3$, it has been found that the usual chamber reactions are accelerated about thirteen times. In lead chambers the ratio is 4 lbs. to 1 lb. $NaNO_3$ equivalent. (1,342,024; June 1, 1920.)

Process of Treating Copper-Bearing Sands.—In the leaching of copper-bearing sands with solutions containing ammonia, difficulty has been encountered in removing the occluded or adsorbed ammonia from the leached material. The loss of solvent has been a source of expense and a cause of low recovery of copper. The ammonia cannot be completely removed by washing with water. A better recovery may be obtained by passing steam through the bed of leached sands and condensing the effluent vapors. The latter method is expensive and entails the use of heavy apparatus to withstand pressure and the apparatus must be made tight to avoid loss.

C. H. BENEDICT and H. C. KENNY of Lake Linden, Mich., avoid the drawbacks attendant with the use of steam under pressure by admitting the steam at atmospheric pressure above the bed of sand and causing it to flow downwardly through the bed by maintaining a partial vacuum beneath the bed. There is some condensation of the steam; this is withdrawn and used as a wash in the treatment of fresh batches of sand. The application of steam is continued with the condensation of effluent vapors until the ammonia content in the condensate falls to a predetermined minimum. The application of steam is then discontinued and hot water distributed uniformly over the upper surface of the bed, the partial vacuum being maintained. The water vaporizes at the diminished pressure as it percolates through the heated sand and the resulting steam entrains the last recoverable trace of adsorbed ammonia. The utilization of the residual heat in the sand avoids the heat losses which obtain where highly heated sands are run directly to waste. (1,335,474; March 30, 1920.)

Process of Recovering Cobalt.—The process consists in roasting the ore in the presence of sulphuric acid, extracting the soluble sulphates with water, precipitating the impurities, such as iron, arsenic and copper, with calcium carbonate, removing the precipitate by filtration, precipitating the cobalt in the filtrate with lime in amount sufficient to form a basic insoluble sulphate. The cobalt is recovered by electrolysis, of a sulphuric acid solution, with insoluble anodes, the electrolyte being maintained at less than 1 per cent acidity by neutralizing the liberated sulphuric acid with the basic sulphate obtained as described. In case copper is not completely precipitated when the solution is treated with calcium carbonate, it may be separated from solution by precipitation on cobalt or removed in a special cell using low voltage. Nickel if present will follow the cobalt through the various steps of the process and, if desirable, can be separated by any of the usual methods. (1,336,765; MARVIN J. UDY of Kokomo, Ind.; assigned to Haynes Stellite Co.; April 13, 1920.)

British Patents

Complete specifications of any British patent may be obtained by remitting 25c. to the Superintendent British Patent office, Southampton Buildings, Chancery Lane, London, England.

Antimony Pigments.—An antimony pigment suitable for vulcanization is produced by decomposing a mixture of an antimony salt with alkali waste liquor by means of an excess of sulphuric or hydrochloric acid. Any proportion of the alkali waste liquor may be replaced by the product obtained by boiling lime with sulphur. (Br. Pat. 138,137—1919. E. F. MORRIS, Roby, near Liverpool, March 31, 1920.)

Synthetic Tanning Products.—Formaldehyde condensation products are obtained by condensing formaldehyde (or substances yielding it) with mixtures of naphthylamine sulphonic acids and aromatic monohydroxy compounds containing acid salt-forming groups, at 60 to 80 deg. C., in the presence of a little sulphuric acid. The resulting solutions may be used directly for tanning, after neutralizing by alkali the free sulphuric acid present. Products of increased tanning value are obtained by neutralizing the free sulphuric acid in the solutions by hydroxides of metals whose salts have tanning properties, as chromium, aluminum or iron, with or without neutralizing the sulpho groups by alkali. (Br. Pat. 138,796—1919. A. G. BLOXAM, DURAND & HUGUENIN, Basel, Switzerland, April 14, 1920.)

Cellulose for Paper Making.—In the preparation of cellulose for paper making from fibrous plants such as maize, alfalfa, dwarf palm, papyrus, etc., the stalks and leaves are cut up, crushed and washed, and then treated by steam at 2 to 3 kg. pressure for one hour in a digester, condensation water being drained away and taking with it parenchymatous cellulose and soluble matters such as gums and pectates. The cellulose fibers swell up and the cement is partly dissolved. The drain cock is then closed and 13 per cent caustic soda is introduced and circulated by a Koerting injector, or by using a digester of the vomiting type, or other means, the operation being conducted for 3 hr. at 2 to 3 kg. pressure. The product is washed, broken in a beating engine or small mill, and bleached, and may be used for half-pulp paper, such as packing paper. Semi-chemical pulp may be obtained by substituting slaked fat lime for the caustic soda, and, by partial bleaching of the half pulp so produced, a pulp suitable for newspaper is obtained. Alkali materials may be recovered by evaporation and re-causticized by the methods usually employed in soda pulp mills. (Br. Pat. 138,911—1919. SOC. ANON. A. OLIER, Clermont-Ferrand, France, April 21, 1920.)

Phenol-Aldehyde Condensation Products.—Soluble condensation products are first obtained from phenols and aldehydes by heating with catalysts such as sodium salicylate or ammonium sulphocyanide, and are then converted into insoluble products by heating with catalysts such as sodium cyanide or ammonium chloride. An example is given of the treatment of phenol and formaldehyde. The products may be used in the manufacture of varnishes, enamels, plastic compositions, insulating materials, combs, phonograph disks and cylinders, etc. They may be mixed with cellulose esters, sugars, albumens, triacetin, tartaric esters, eugenol, camphor, coloring matters, etc. (Br. Pat. 139,147—1919. L. JALOUSTRE, Z. KHEIFETZ and M. WARCHAVSKY, Paris, April 21, 1920.)

Oxyaldehydes.—Oxyaldehydes and their ethers are produced by the interaction of a phenol or its ether, formaldehyde, and a nitroso compound. The preparation of vanillin by treating guaiacol and formaldehyde with p-nitrosodimethylaniline is described. Anisol aldehyde, pyrocatechin aldehyde and salicylic aldehyde are also referred to. (Br. Pat. 139,153—1919. A. WEISS, Lyons, France, April 21, 1920.)

Sulphur Dioxide From Slag.—Sulphur dioxide sufficiently concentrated for the production of a sulphuric acid is obtained by oxidizing the sulphides in liquid blast-furnace slag by passing a limited amount of air or oxygenated air over or through the slag, or both, or by adding an oxidizing agent such as calcium or magnesium sulphate to the slag, or by both adding such an agent and treating with air. The oxidizing agent may be pre-heated and may be used in molten condition. For this purpose, calcium sulphate may be fused with a small proportion of a flux such as sodium chloride or calcium fluoride. The treatment of the slag is such as not to cause solidification. For instance, the air may be blown through the slag, and the hot air arising therefrom may be passed over the slag as it runs along a covered channel in counter-current. The liberation of the sulphur dioxide may be facilitated by stirring or by blowing in heated air, but the quantity of air should not in any case be such as to yield a product containing less than 4 per cent of sulphur dioxide by volume. The slag may be treated in a slag-pan provided with a hood, dip-pipe and gas outlet, or in one of several covered slag sumps disposed in the slag run. The treated slag is suitable for the manufacture of slag cement, slag wool, etc. (Br. Pat. 139,172 and 139,173—1919. L. H. DIEHL, Berlin, April 21, 1920.)

Cellulose Acetates.—Cellulose acetate is formed by adding a halogen, such as chlorine or bromine, to a mixture of cellulose, acetic acid and acetic anhydride. A halogen acetic acid is formed and acts in its nascent state as a condensing agent. When the action is completed (after about 2 hr. at 70 deg. C.), further esterification is brought about by the addition of a strong acid such as sulphuric or chlorsulphonic acid. The solution may be used for directly making films, artificial silk, horsehair, etc., or the ester may be precipitated. The halogen has also a hydrolytic action upon the cellulose and this action may be varied by varying the temperature (up to 80 deg. C.), the amount of halogen or the length of time of the action. A further hydrolysis may be effected by adding dilute acetic or other acid, formaldehyde or hydrogen peroxide. Esters are obtained which yield solutions of low viscosity in acetone, chloroform, or in mixtures of acetone and alcohol, or of acetone, alcohol and benzol. (Br. Pat. 139,232. J. O. ZDANOWITCH, London, April 28, 1920.)

Chlorination and Sulphonation.—The sulphonation or chlorination of aromatic compounds, such as benzene, toluene or phenol, is effected by atomizing the aromatic compound and sulphuric acid or liquid chlorine into a chamber, from which the mixture passes to a second chamber provided with heating or cooling coils; the product is drawn off from the lowest chamber. The production of benzene monosulphonic acid and chlorbenzene is described. In the case of chlorination, the second chamber contains a catalyst, such as aluminum chloride or ferric chloride. (Br. Pat. 140,007—1919. H. N. MORRIS, Manchester, May 5, 1920.)

Current Events
in the Chemical and Metallurgical Industries

Hearing on Minerals Separation-Miami Contempt Proceedings

At Wilmington, Del., on June 15, a motion to dismiss the petition of Minerals Separation, Ltd., seeking to punish Miami Copper Co. for contempt of court, was heard. The petition also asked an extention of injunction to cover the present operations of that company.

The Miami company held that such a petition for contempt and extension of injunction was not warranted by the facts. It took the ground that such action, under the circumstances, was not the proper procedure. Such action by the court before the Miami company's witnesses had also testified before the Master, it was claimed, would be unfair to the defendant, since the processes enumerated in the petition were the very ones to which so large a part of the testimony already given before the Master referred. Judge Bourquin's decision in the Butte & Superior contempt proceedings (CHEM. & MET. ENG., June 16, 1920, pp. 1099 and 1131) was cited, Miami claiming its case analagous.

Minerals Separation eventually admitted that Miami should have an opportunity to cross-examine Minerals Separation witnesses. Much of the arguments of Minerals Separation counsel was devoted to emphasizing the violence of agitation in various steps of Miami process. Miami counsel, however, made their contention strictly one of procedure.

Miami Petition to Reopen Case Denied

The United States Circuit Court of Appeals of Philadelphia has declined to reopen the case of Minerals Separation, Ltd., vs. the Miami Copper Co. on petition of the latter to admit newly discovered evidence. The order of the court in this matter was filed June 18. While it declines to reopen the case, the court states that it expresses no opinion as to the relevancy and competency of the subject matter of the Miami petition on questions arising in the accounting before the Master.

Large Pulp and Paper Combination Formed

A big combination of pulp and paper manufacturers of Canada has been formed by the merger of the Riordon company of Montreal and the Edwards, the Bronson, and the Gilmour & Hughson companies of Ottawa. This merger, which is a $60,000,000 affair, will control greater pulp wood and timber limits than any other single management in the Dominion.

It will control 12,000 square miles of timber lands in the Ottawa River Valley, containing about 25,000,000 cords of pulp wood, 1,200,000,000 ft. of standing pine and other woods, in addition to water facilities for generating 150,000 hp. The tract is said to be the largest known remaining source of pulp wood and pine in Canada. The pulp and paper output of the new corporation as estimated will be 150,000 tons, while 125,000,000 ft. of pine will also be cut.

Crown-Willamette Installs New Sulphurous Acid System

The Crown-Willamette Paper Co., operating large mills at Camas, Wash., and West Lynn, Ore., and also, under the name of Pacific Mills, Ltd., another mill at Ocean Falls, B. C., has installed the Jennsen tower system for the production of sulphurous acid at the Camas plant. This is the first use of the new system in paper mills on the Pacific Coast. The feature of the Jennsen system consists of high concrete towers which are filled with raw limestone, calcined dolomite being used in this case. Through this rock sulphur dioxide is passed in solution. Under the older and more expensive process, bubbles of sulphur dioxide were passed through a vat containing milk of lime. Efficiency and economy of operation and a greater uniformity of product are advantages of the Jennsen system. If the new process proves up to expectations, it will be installed in all three plants operated by the company.

Another innovation recently inaugurated by the Crown-Willamette Paper Co. is the bringing of sulphur by water instead of by rail from the Gulf of Mexico to Portland, Ore., for distribution to the two plants near that city. The sulphur, as well as the lime rock, is handled entirely in bulk. The rock is to be brought from Puget Sound to Portland by a fleet of sea-going barges.

This same paper company has just purchased 17,500 acres of timber land in Necanicum County, Ore., which cruises a total of 650,000,000 ft. of standing timber. Spruce and hemlock comprise 88 per cent of this timber. The supply is sufficient to keep the mills running for twenty years.

Committee Urges Development of Alaska's Pulp Wood

In a special report to the Secretary of the Interior the Alaska Advisory Committee urges that an intensive campaign be made for the development of Alaska pulp wood. The committee is charged with the duty of searching out ways to better conditions in Alaska and particularly to stimulate industries so as to provide tonnage for the new Alaska railroad.

The committee points out that an ultimate possible annual production of 2,000,000 cords of pulp wood may be obtained from Alaska timber and recommends that the Government launch an intensive campaign for its development. Attention is called to the fact that the water-power resources of Alaska can be used to advantage in this development.

The report declares that 60 per cent of the population of the territory in the past has been directly or indirectly employed by the gold mining industry. To the decline in gold mining is laid the principal blame for Alaska's loss in population and the discouragement of her residents. Thus the maximum prosperity of the territory must await a revival of gold mining.

Water-Power Bill Signed by the President

After twelve years of consideration, Congress at last has adopted a water-power policy and has prescribed exact conditions under which the nation's white coal may be used. The final step, so far as Congress is concerned, was taken May 28 when the Senate, by a vote of 45 to 21, approved the conference report on the water-power bill. The bill was signed by the President prior to June 11 under a formal opinion by the Attorney-General that the adjournment of Congress does not deprive him of the ten days allowed by the Constitution for the favorable consideration of a measure.

While much of the delay in securing this legislation has been due to the difficulty of determining in advance a policy in a matter which has so many ramifications and intricacies, the main conflict has been between those who were emphasizing what they conceived to be necessary in the public protection, as against those who were struggling to secure a law of sufficient liberality to attract capital. In the enactment of some of the so-called conservation measures, the conservation idea was so emphasized that capital could not be interested, with resultant stifling of development.

Believed Capital Will Be Attracted

The water-power bill, just signed, contains many restrictions, but it is believed that capital can be attracted to water-power development under its provisions. It is realized that modifications are certain to be made in the light of experience, and capital apparently is hopeful that it will have an opportunity to make a fair rate of return on investment. On the other hand, in conservation circles, the opinion seems to prevail that the bill is unnecessarily liberal and that the last of the great national resources is being disposed of without proper protection of the interests of the general public.

Much Power Gone to Waste

During the long wrangle over the water-power policy, it is admitted that the country has suffered very large losses through allowing water power to go to waste. Senator Wesley L. Jones, of Washington, the chairman of the Senate Committee on Commerce, under whose jurisdiction the bill comes, estimates that the delay in fixing fair and reasonable terms for the use of water power resulted in the United States being found at the beginning of the World War with 5,000,000 hp. of developed hydro-electric energy, instead of 20,000,000 hp. which it should have had. Caught in the pinch of war, Senator Jones points out, the nation was soon short of coal, short of oil and short of power. Half a billion dollars had to be expended within two years in the erection of steam power plants, just at a time when the capital, labor and material were most needed for other purposes in the prosecution of the war.

Estimates as to the potential water power in the United States vary greatly, but the calculations of the United States Geological Survey place the minimum potential water power of the country at about 35,000,000 hp. and the assumed maximum at something over 65,000,000 hp. This estimate does not take into consideration the increases in horsepower which it will be possible to obtain by providing for storage of water.

Commission to Administer the Act

The act is to be administered by a Federal Power Commission which is to be composed of the Secretaries of War, Interior and Agriculture. The direct administration of the law, however, falls upon an executive secretary. The commission is charged with forty-five specific functions or duties. It has administrative control over all power sites on the navigable waters and on the public lands and reservations of the United States. It is to have to do with the location, design, construction, maintenance and operation of power projects upon such sites. Under certain conditions it must regulate financial operations and fix rates for service, to say nothing of making physical valuations of properties. In addition, the commission is charged with general investigations covering a wide field.

Specific Functions of the Commission

Among the specific functions of the commission are the following:

To issue licenses for power projects and transmission lines on navigable waters, public lands and reservations of the United States.

To investigate and approve all contracts for power made by a licensee which will extend beyond the termination of the license.

To prescribe rules for, and to fix annual license charges and to determine the relation of such charges to prices to consumers.

To hold hearings when desirable or necessary in connection with any application for a permit or license.

To see that projects are best adapted to a comprehensive scheme of improvement and utilization.

To require that project works be properly maintained and kept in efficient operating condition.

To keep in touch with conditions of the power market tributary to every development in order to require extensions as rapidly as conditions warrant.

To prescribe a system of accounting for licenses.

To prescribe rules for the establishment and maintenance of depreciation reserves.

To devise principles for the proper apportionment of surplus earnings to amortization reserves.

To regulate under certain conditions the amount and character of securities which may be issued for the financing of power projects.

To make valuation of all projects brought under license which have been constructed in whole or in part, prior to the application for license.

To determine the net investment and severance damages in the event that properties of the licensee are taken over by the United States at the termination of a licensed period.

Commission Also to Collect Data

In addition, the Commission is charged with the collection and reporting of data concerning:

The utilization of the water-power resources of any region to be developed.

The water-power industry and its relation to other industries and to interstate and foreign commerce.

The location, capacity, development costs and relation to water-power sites.

Whether the power from Government dams can be used advantageously by the United States for its public purposes and what is the fair value of such power.

To determine whether lands of the United States reserved as power sites may be open to entry subject to a reservation of the power rights of the United States.

Deterioration of structures and equipment for the purpose of establishing rates of depreciation and the amount of annual depreciation reserves.

Special Investigations to Be Made

In addition there are a number of special investigations which the Commission must make. One of these is to estimate the cost and economic value of generating hydro-electric power at Great Falls, on the Potomac River, near Washington. The opening up of the nation's water powers is expected to be of special stimulus to the chemical industry.

New Jersey Chemical Society Holds Meeting at Rutgers College

The June meeting of the New Jersey Chemical Society was held at Rutgers College, New Brunswick, by invitation of the Chemical Department, on the afternoon and evening of June 5, and, in spite of the heavy rain, a fair number of out of town members were present. The storm prevented inspection of the college farm, as well as the buildings and grounds, as had been planned, and the afternoon session was devoted to the series of motion pictures contributed by the Goodyear Tire & Rubber Co. of Akron, Ohio.

These showed the entire history, from the collection of the rubber latex, on the company's plantations in Sumatra, through each step in the manufacture, to the final inspection of automobile tires. It was an exhibit of the greatest educational value and intensely interesting.

After dinner had been served in the college dining hall, the evening meeting was begun by an address by Dr. Jacob G. Lipman on the uses of sulphur in agriculture. After showing that the sulphur required by some crops was not present in some soils, Dr. Lipman described his own discovery of oxidizing bacteria on sulphur and finely ground phosphate rock in stable manure, which makes both the sulphur and phosphoric acid available.

A lecture was given by Dr. D. A. Lyon, of the Bureau of Mines, Washington, D. C., on the hydrometallurgy of copper illustrated by motion pictures of the extensive leaching and electro-deposition works at Ajo, Ariz. The processes employed have been so perfected that less than 2 per cent of copper makes the ore worth working, and the pictures gave a clear presentation of the operation of the project.

Awards Recommended by Minerals Relief Commission

A total of $1,238,451.12 has been recommended by the War Minerals Relief Commission for awards to claimants who produced chrome, manganese, tungsten and pyrites in response to the Government's war-time request or demand. This represents 32.6 per cent of the amount asked by the claimants. The total claimed in the cases in which these awards were made was $3,798,756.09. These figures include all claims in which recommendations have been made up to and including the week ended June 12.

Results of Government Nitrate Sales

Not more than 100 tons of the Government's nitrate of soda has been sold under the special statute enacted shortly before the close of the last session of Congress. The act authorized the sale of 100,000 tons of the Government's reserve of nitrate.

The nitrate is being offered at $88.90 a ton. At many points regular dealers in nitrate are making sales at lower figures. It is believed, however, at the War Department that the law at least had the effect of stabilizing the nitrate market.

All orders that have been placed are for ton lots. It is believed by Major J. H. Hunter, the officer in charge of the distribution, that the volume of buying will increase decidedly as the fact becomes more widely known that the War Department is conducting this sale of the material. At several of the points where the nitrate is in storage the Government price is lower than the price in the open market. It is not anticipated, however, that more than 20,000 tons will be sold under the act, which expires Oct. 20.

It is admitted that a larger volume of the nitrate would have been sold had it become available earlier in the year, but owing to the late season it could have been utilized to practically the same advantage had it been purchased when first available. For that reason some are of the opinion that the scarcity of nitrate is nothing like as great as was represented in Congress.

Procter & Gamble to Build Soap Plant in California

An option on about thirty acres of land in the San Francisco Bay district has been taken by representatives of the Procter & Gamble Co. upon which to build a new soap plant. At the beginning about 500 will be employed, but it is expected that double that number will be required shortly.

Personal

ELMER D. BALL, of the Iowa Agricultural College, has been appointed Assistant Secretary of Agriculture. For more than twenty years Mr. Ball has been engaged in investigation and research on agricultural problems or teaching in agricultural colleges.

WALTER M. BERRY, chemist in charge of the gas engineering section of the Bureau of Standards, has just started on a trip through the far West in connection with the Bureau work on gas quality standards and the activities of state public service commissions.

EDWARD CALDWELL, treasurer of McGraw-Hill Co., Inc., and treasurer and director of the McGraw-Hill Book Co., was tendered a dinner by his business associates in commemoration of his thirty years of service with these companies. Mr. Caldwell's first connection with technical journalism was as assistant editor of *Electrical World* in June, 1890. Among other activities he developed the book department of the McGraw Publishing Co. and was later instrumental in effecting the consolidation with the book department of the Hill Publishing Co., known as the McGraw-Hill Book Co. Among his early activities was that of business manager of *Electrochemical Industry*, the forerunner of CHEMICAL & METALLURGICAL ENGINEERING.

EUGENE B. CLARK has been made president of the American Ore Reclamation Co. and of the American Sintering Co., to fill the vacancy caused by the death of James Gayley.

SIDNEY CORNELL, chemical and industrial engineer, has moved his office from 1 West 34th St. to 80 Maiden Lane, New York City. He is spending the summer at Ogunquit, Me.

Dr. F. G. COTTRELL's nomination as director of the Bureau of Mines was confirmed by the Senate shortly before the adjournment of Congress.

Dr. FREDERIC DANNERTH, who was retained by the C. Kenyon Co. of Brooklyn, N. Y., as consulting chemist, has recently declined the invitation to become head of the new laboratories. The new development department was planned and organized by him and this work was recently completed.

Dr. HENRY S. DRINKER announced his retirement from the presidency of Lehigh University, Bethlehem, Pa., on June 15, 1920. Dr. Drinker was graduated from Lehigh University in 1871, in which year he was one of the founders of the American Institute of Mining Engineers. Since that time he has been devoted to the service of the university, serving as secretary of the alumni, president of the alumni, alumnus trustee, trustee and president.

HENRY B. FABER received the honorary degree of Doctor of Science at Emory University, Atlanta, Ga., on June 10. Dr. Faber is a consulting chemical engineer in New York City, a member of the advisory board of the Chemical Exposition and until recently was actively connected with the Industrial Filtration Co.

EDGAR S. GENSTEIN, formerly engineer of tests, U. S. Naval Ordnance Plant, Charleston, W. Va., is now metallurgist for the Treadwell Engineering Co., Easton, Pa.

E. P. MATHEWSON has been appointed consulting metallurgist to the Granby Consolidated Mining, Smelting & Power Co.

STANLEY P. ROCKWELL has resigned his position as vice-president of Weeks-Hoffman Co., Syracuse, N. Y., to become metallurgist at Whitney Mfg. Co., Hartford, Conn., the change to take place July 1, 1920.

WILLIAM YOUNG WESTERVELT, consulting mining engineer, announces the removal of his office to the Fifth Avenue Guaranty Building, 522 Fifth Ave., New York City.

Obituary

OSCAR H. EBERT, treasurer of the Baugh & Sons Co. and the Baugh Chemical Co., with offices and plants at Philadelphia, Baltimore and Norfolk, died suddenly at his home in Baltimore on Wednesday, June 2, from an attack of acute indigestion, which brought on heart failure. He was ill only one day, and his death came as a great shock to his many friends in the fertilizer industry. Mr. Ebert was fifty-eight years old, and had been connected with the Baugh company more than forty-one years.

WHITFIELD P. PRESSINGER, of New York, vice president Chicago Pneumatic Tool Co., died June 10 as a result of complications following an operation. Mr. Pressinger was actively engaged in the pneumatic tool and allied machinery industry for many years. He was general manager of the Clayton Air Compressor Co. for seven years and became widely known through numerous activities in the American Society of Mechanical Engineers and the Compressed Air Society. He was born in New York City in 1871. In addition to the foregoing societies he was a member of the Sons of the Revolution, 7th N. Y. Regiment Veterans, F. and A. M., and the following clubs of New York City: Engineers, Lawyers, New York Athletic, New York Railroad, Columbia Yacht, and the Machinery Club.

HENRY E. SURFACE, a chemist of national authority on paper and valuation work, was killed in the disastrous wreck Wednesday, June 9, on the N. Y. Central Railroad, at Schenectady, N. Y. He is survived by a widow, Mary Hubbard Surface, and a son, Henry, Jr.

Current Market Reports

The Non-Ferrous Metal Market

New York, June 21, 1920.—A sharp drop in the London copper market caused a depression in this city. Large sellers quote 19c. for June-July deliveries, as before, but in outside market 17.75c. will buy spot copper, 18c. July-August. The tin market is a shade stronger than last week.

	Cents per Lb.
Copper, electrolytic	18.50
Aluminum, 98 to 99 per cent	34.00
Antimony, wholesale lots	8.00
Nickel, ordinary	42.00
Nickel, electrolytic	45.00
Tin, Straits, spot	46.25
Lead, New York, spot	8.00
Lead, E. St. Louis, spot	7.75
Zinc, spot, New York	7.87½
Zinc, spot, E. St. Louis	7.50

OTHER METALS

Silver (June 17)	oz	$0.99½
Cadmium	lb.	1.40@1.50
Bismuth, (500 lb. lots)	lb.	2.70@3.00
Cobalt	lb.	2.50
Magnesium (f.o.b. Niagara Falls)	lb.	1.60@1.85
Platinum	oz.	75@85
Iridium	oz.	300@400
Palladium	oz.	70@80
Mercury	75 lb.	90@92

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	33.50
Copper bottoms	38.00
Copper rods	38.00@40.00
High brass wire and sheets	30.25
High brass rods	25.00
Low brass wire and sheets	28.50
Low brass rods	29.00
Brazed brass tubing	43.25
Brazed bronze tubing	41.75
Seamless copper tubing	34.00
Seamless high brass tubing	33.00

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	24.00@24.50
Aluminum, sheet scrap	24.00@24.50
Copper, heavy machinery comp.	15.00@15.50
Copper, heavy and wire	14.25@14.75
Copper, light and bottoms	12.50@13.00
Copper, heavy cut and crucible	15.00@15.50
Brass, heavy	9.00@10.00
Brass, light	7.50@8.00
No. 1 clean brass turnings	9.25@9.75
No. 1 comp. turnings	13.00@13.50
Lead, tea	5.00@5.50
Lead, heavy	7.00@7.25
Zinc, scrap	5.00@5.25

The Iron and Steel Market

Pittsburgh, June 18, 1920.

The course of the iron and steel markets has been quite uneventful in the past week. Buying of pig iron continues at a minimum, although there are occasional transactions. In steel there is free buying from the Steel Corporation, but limited business on the part of the independents, the explanation of the divergence being of course the wide difference in prices.

There is absolutely no snap in the market. Buyers take hold for only absolutely known requirements. They seem quite indisposed to consider any business except what it is certain they must place, and show signs of being on the lookout for a good opportunity to relax their efforts and await a more convenient season for activity. Almost throughout the industries there is a growing feeling that it is altogether too difficult to do business, costs being so high and performance on all hands so indifferent. Many observers insist the country needs "the rest cure" and will not be able to do good work until this corrective influence to the present ills has been applied. There is even, perhaps, a disposition on the part of some producers to apply the remedy, possibly in homœopathic doses, in the not distant future.

TRANSPORTATION CONDITIONS IMPROVING SLOWLY

Transportation conditions continue to improve, but very slowly indeed. Early in the week there was a backset in the matter of car supplies to some mills, due to the inauguration of the lake ore and lake coal pools, but this is only temporary, it is claimed, incident to starting the new system, which is expected to result in better service in moving coal to Lake Erie and bringing ore back, in proportion to the number of cars in the service.

In occasional instances steel mills are now shipping as much steel as they produce, but the general average is not as favorable as that, and outside the tin-plate industry there has been no noticeable reduction in the stocks of steel accumulated at any of the mills.

In tin plate excellent results have followed the preference accorded to box car supplies to tin mills, at the instance of the Interstate Commerce Commission. The tin-plate stocks at mills, fully 2,500,000 boxes, equal to the production of about one billion 2-lb. cans, or about one-seventh of the normal requirements of the fruit and vegetable packers, have been reduced to about 1,500,000 boxes, and the current make, at between two-thirds and three-fourths of capacity, has been shipped besides.

Production continues to increase by both blast furnaces

and steel works, and this despite the continued shortage of both coal and coke. The rates of production in both pig iron and steel are now nearly if not altogether up to the rates of last March, the highest since October, 1918, about 40,000,000 tons a year in pig iron and 45,000,000 tons in steel ingots.

Prices in general show no material change. Pig iron is firmly maintained by the furnaces, which experience no difficulty in securing full prices for such prompt deliveries as are called for, while there is little inquiry for second half to tempt price concessions even if sellers were so disposed. There are reports of a few consumers requesting postponements in deliveries, perhaps a reaction from the heavier shipments the furnaces are able to make as car supplies improve.

Prompt deliveries of steel products continue to show a declining tendency, but prompt deliveries have at no time comprised any large part of the turnover. The larger independent mills, able to make shipments in from two to four months, are firm in their price views, and naturally so since the business on books needs to be protected. It is recognized that in the easier general conditions that now obtain requests for postponements or cancellations are a possibility. As to the Steel Corporation, it pursues the even tenor of its way, with its Industrial Board prices, far below the prices of independents, tonnages being allotted from time to time to regular customers for shipment in the indefinite future, and following the shipment of tonnage already on books.

Labor Contest in Prospect

The uninteresting perennial, the sheet and tin plate wage scale settlement between the Amalgamated Association and the sheet and tin mills, about 40 per cent of the total number which sign tonnage wage scales annually with the association, has this year developed news, and a contest of such proportions as circumstances would permit is in prospect. The men had their usual demands for wage advances, and repeated the demand of a year ago for a 6-hr. instead of the thoroughly established 8-hr. shift, and from these demands there would probably have been the usual complete or nearly complete recession, but an entirely novel demand was made, that there should be inserted in the "preamble" to the scale a proviso that the manufacturers signing the scale book—the various tonnage wage scales, for iron mills, sheet and jobbing mills and tin mills are all printed in the one book—should thereby agree to allow the Amalgamated Association a free hand in organizing any other departments the various companies might have. This novel demand seems to have resulted from expectations on the part of the Amalgamated Association officials that the American Federation of Labor might undertake seriously to organize the iron and steel industry, and a feeling that the Amalgamated Association, while small now, is the "logical" body for doing any organizing if there is organizing going to be done. The manufacturers, of course, could not agree, and when it was proposed, at last Monday's session of the conference at Atlantic City, that an adjournment be had to the last week in June, the existing scales expiring June 30, the workers rejoined that if there were going to be an adjournment it would be to the first week in September, as the workmen desired a vacation and the manufacturers seemed to need time for reflection. Adjournment thereupon occurred promptly. Approximately 60 per cent of the sheet and tin mills, about a thousand all told, are non-union, including all those of the Steel Corporation, about 40 per cent of the total. The prospect is that the Amalgamated Association will be eliminated. Except in the sheet, tin plate and iron mill industries it has not been a factor since the Homestead strike of 1892.

The Chemical and Allied Industrial Markets

New York, June 18, 1920.

Developments in the chemical market during the past week have been few, with a slight falling off in demand as the most noticeable feature. As has been the case for some time back, more attention is displayed in locating certain of the more active items than in the actual price that is being asked. Among the *acids* which have been generally scarce for some time fair-sized offerings of *sulphuric*, 60 deg., at \$14@\$19 per ton, in tank cars, have been made, and there is also 1,200 tons of 66-deg. available for prompt shipment from Nitro, W. Va., quoted at \$23@\$26 per ton, sellers' tanks. *Acetic acid*, glacial, is easier with \$16.50 per cwt. as the prevailing quotation on a quantity of three carloads of this material. *Muriatic* is well sustained at \$3.50 per cwt. as the average quotation, while, on the other hand, producers are finding it difficult to meet their contracts for *oxalic*, crystals, for which as high as 65c. per lb. is being asked, but owing to the small stocks on hand it is difficult to determine whether this is an actual sale price or a nominal quotation. It is reported that there is a considerable supply of *anhydrous ammonia* in Philadelphia, but owing to the scarcity of cylinders the producers have been unable to make deliveries. This material is being offered, to those who can furnish cylinders, at 35@45c. per lb. for prompt shipment. The present scarcity of *barium chloride*, brought about by two causes, first the switching of many users from *blanc fixe* to this item during the war and secondly the destruction of the plant belonging to the largest factor in this market, has placed it in a nominal position. There is no immediate relief in sight and \$150@\$180 per ton will continue as the listing for some time. The *formaldehyde* situation seems to be somewhat easier and although production is nowhere near normal, because of the short supplies of *alcohol*, nevertheless an offering of a 50-bbl. lot at 52c. was heard during the week.

Coal-Tar Products

This market is reported on the decline, but as yet no evidence in price changes can be observed. Now that the break is supposed to have occurred, buyers are anxiously waiting to see how far prices will drop. The export business is in as bad condition as it has ever been previously, the war excepted, and with Japan not only out of the buying position but offering resale material below the domestic market, the present waiting position of the buyer seems to be justified. Against this, however, there is the shortage of crude materials and poor transportation facilities to weigh before definitely deciding a big slump is due. *Alpha naphthylamine* dropped to 55@60c., against 65@70c. of the previous week, but even at the new level there has been very little activity. With the principal producer completely sold up on *naphthalene*, there is very little material to be had of any grade except in small resale lots, which are commanding 17@18c. for *flake* and 16@17c. for *balls*. *Paradichlorbenzol* came down slightly and is now listed at \$1.50@\$1.55 per lb., against \$1.65 previously quoted.

Waxes

Interest in this market continues to center on the *paraffine* grades, which have come up throughout the list. No contracts for large quantities are being placed and the prices quoted are those prevailing on the small resale lots which are jumping around the trade.

Miscellaneous Materials

Barytes, quoted f.o.b. Kings Creek, advanced approximately \$2 a ton on both the ground white and off-color product, moving upward from \$20@\$22 and \$16@\$18 respectively as per last week's quotation to \$22@\$25 and \$18@\$20. *Feldspar*, ground, in car lots, f.o.b. Baltimore, showed an advance from \$18 to \$22 per gross ton.

Inquiries for *graphite*, especially the 90 per cent grade of flake, at prices ranging from 8½c. to 9c. per lb., f.o.b. Ashland, Ala., continue strong. It is reported that during the week a shipment of one 60,000-lb. car of 85 per cent guaranteed *carbon*, Alabama flake, was shipped at 11c. delivered. Accumulated stocks are being cleaned up rapidly through the heavy demand for both the lubricating and the 90 per cent crucible grades, and indications are that prices will show a rise if the domestic material continues in use.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.		$0.65 – $0.75
Acetone	lb.	$0.15 – $0.20	.21 – .22
Acid, acetic, 28 per cent	cwt.	3.50 – 3.75	4.00 – 4.50
Acetic, 56 per cent	cwt.	6.00 – 7.50	8.00 – 9.00
Acetic, glacial, 99½ per cent, carboy	cwt.	15.50 – 16.00	16.50 – 17.50
Boric, crystals	lb.	.15 – .15½	.15½ – .16½
Boric, powder	lb.	.15 – .15½	.15 – .16
Citric	lb.	1.05 – 1.12	1.17 – 1.18
Hydrochloric (nominal)	cwt.	2.00 – 3.00	3.50 – 4.00
Hydrofluoric, 52 per cent	lb.	.13½ – .14	.14½ – .15½
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.04½ – .05½	.06 – .07
Molybdic, C. P	lb.	4.00 – 4.50	4.50 – 5.00
Muriatic, 20 deg. (see hydrochloric)			
Nitric, 40 deg	lb.	.06 – .7	.07½ – .08½
Nitric, 42 deg	lb.	.07½ – .08	.08½ – .09½
Oxalic, crystals	lb.	.55 – .57	.60 – .65
Phosphoric, Ortho, 50 per cent solution	lb.	.14 – .23	.24 – .25
Picric	lb.	.28 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.25 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	14.00 – 19.00	
Sulphuric, 60 deg., drums	ton		
Sulphuric, 66 deg., tank cars	ton	23.00 – 24.00	25.00 – 26.00
Sulphuric, 66 deg., drums	ton	35.00 – 40.00	45.00 – 50.00
Sulphuric, 66 deg., carboys	ton	36.00 – 40.00	50.00 – 55.00
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	37.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 – 30.00	38.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 –
Tannic, U. S. P	lb.	1.45 – 1.50	1.55 – 1.60
Tannic (tech.)	lb.	–	.60 – .90
Tartaric, crystals	lb.	–	.80 – .85
Tungstic, per lb. of WO	lb.	–	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl, 95%	gal.	–	2.50 – 2.70
Alcohol, Methyl, pure	gal.	–	3.50 – 3.55
Alcohol, denatured, 188 proof (nominal)	gal.	–	1.10 – 1.15
Alcohol, denatured, 190 proof (nominal)	gal.	–	1.05 – 1.10
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.07½ – .08½	.09 – .09½
Alum, chrome lump	lb.	.15½ – .18	.19 – .20
Aluminum sulphate, commercial (nominal)	lb.	.02 – .03	.03½ – .04½
Aluminum sulphate, iron free	lb.	.03½ – .04	.04½ – .04½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ – .10½	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.32 – .35	.35 – .40
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.12½ – .13½	.13½ – .14½
Ammonium nitrate	lb.	.08½ – .09½	.10 – .11
Ammonium sulphate	lb.	.07 – .07½	.08½ –
Amylacetate	gal.	–	5.00 –
Amylacetate tech	gal.	–	4.75 – 5.25
Arsenic, oxide, lumps (white arsenic)	lb.	.15½ – .16	.16½ – .17
Arsenic, sulphide, powdered (red arsenic)	lb.	.20 – .21	.22 – .23
Barium chloride	ton	150.00 – 160.00	170.00 – 200.00
Barium dioxide (peroxide)	lb.	.21 – .23	.24 – .25
Barium nitrate	lb.	.09½ – .11	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ – .05	.05½ – .06
Bleaching powder (see calcium hypochlorite)			
Blue vitriol (see copper sulphate)			
Borax (see sodium borate)			
Brimstone (see sulphur, roll)			
Bromine	lb.	.70 – .90	1.00 – 1.05
Calcium acetate	cwt.	3.50 – 3.55	
Calcium carbide	lb.	.04½ – .04½	.04½ – .05½
Calcium chloride, fused, lump	ton	23.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01½	.02 – .02½
Calcium hypochlorite(bleaching powder)	cwt.	4.00 – 4.25	4.50 – 6.50
Calcium peroxide	lb.	–	1.50 – 1.70
Calcium phosphate, monobasic	lb.	–	.75 – .80
Calcium sulphate, pure	lb.	–	.25 – .30
Carbon bisulphide	lb.	.08 – .09	.10 – .11
Carbon tetrachloride, drums	lb.	.11 – .11½	.12 – .15½
Carbonyl chloride (phosgene)	lb.	–	.80 – 1.05
Caustic potash (see potassium hydroxide)			
Caustic soda (see sodium hydroxide)			
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 – .09½	.10 – .10½
Chloroform	lb.	.30 – .35	.36 – .38
Cobalt oxide	lb.	–	2.00 – 2.05
Copperas (see iron sulphate)			
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	–	.65 – .70
Copper sulphate, crystals	lb.	.08 – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)			
Epsom salt (see magnesium sulphate)			
Ethyl Acetate Com. 85%	gal.	1.35 –	1.40 –
Ethy Acetate pure (acetic ether 98% to 100%)			1.75 –
Formaldehyde, 40 per cent (nominal)	lb	.36 – .40	.57 – .65
Fusel oil, ref	gal.	–	5.25 – 6.00
Fusel oil, crude (nominal)	gal.	–	
Glauber's salt (see sodium sulphate)			
Glycerine	lb.	–	.26½ – .28½
Iodine, resublimed	lb.	4.30 – 4.35	4.40 – 4.45
Iron oxide, red	lb.	–	.03 – .20
Iron sulphate (copperas)	cwt.	–	2.90 – 3.10
Lead acetate, normal	lb.	–	.13½ – .16
Lead arsenate (paste)	lb.	.11 – .12	.13 – .17
Lead nitrate, crystals	lb.	–	.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	–	1.50 –
Magnesium carbonate, technical	lb.	.12 – .14	.15 – .16
Magnesium sulphate, U. S. P	100 lb.	3.00 – 3.55	4.00 – 4.50
Magnesium sulphate, commercial	100 lb.	–	3.25 – 3.60
Nickel salt, double	lb.	–	.14 – .16
Nickel salt, single	lb.	–	.16 – .18
Phosgene (see carbonyl chloride)			
Phosphorus, red	lb.	.50 – .55	.60 – .65
Phosphorus, yellow	lb.	–	.35 – .37
Potassium bichromate	lb.	.35 – .37	.45 – .46
Potassium bitartrate (cream of Tartar)	lb.	.52 – .56	.57 – .58
Potassium bromide, granular	lb.	.80 – .85	.90 – .95
Potassium carbonate, U. S. P	lb.	–	.85 – .88
Potassium carbonate, crude	lb.	.21 – .25	.26 – .28
Potassium chlorate, crystals	lb.	$0.15 – $0.16	$0.21 –
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.31 – .35
Potassium iodide	lb.	–	3.35 – 3.60
Potassium nitrate	lb.	.15 – .17	.19 – .21
Potassium permanganate	lb.	.75 – .80	.85 – .95
Potassium prussiate, red	lb.	.90 – 1.00	1.05 –
Potassium prussiate, yellow	lb.	.32 – .36	.35 – .36
Potassium sulphate (powdered)	ton	$225.00 – 240.00	
Rochelle salts (see sodium potas. tartrate)		–	
Salammoniac (see ammonium chloride)		–	
Sal soda (see sodium carbonate)		–	
Salt cake	ton	28.00 – 32.00	
Silver cyanide (nominal)	oz.	–	1.25 –
Silver nitrate (nominal)	oz.	–	.74 – .76
Soda ash, light	100 lb.	–	3.50 – 3.60
Soda ash, dense	100 lb.	–	3.55 – 3.65
Sodium acetate	lb.	.08½ – .09	.09½ – .12
Sodium bicarbonate	100 lb.	2.25 – 2.60	2.75 – 3.50
Sodium bichromate	lb.	.30 – .33	.34 – .3
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.06 – .06½	.07 – .10½
Sodium borate (borax)	lb.	.09 – .10	.11 – .12
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	.10 – .10½	.10½ – .11
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.18 –	.19 – .20
Sodium hydroxide (caustic soda)	100 lb.	4.25 – 6.00	6.25 – 6.50
Sodium hyposulphite	lb.	–	.03 – .04
Sodium molybdate	lb.	2.50 –	3.25½ –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.19 – .19½	.20 – .21
Sodium peroxide, powdered	lb.	.32 – .35	.35 – .40
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	–	.39 – .40
Sodium prussiate, yellow	lb.	.23 – .27	.31 – .32
Sodium silicate, solution (40 deg.)	lb.	.01½ – .01½	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.60 – 1.70	1.75 – 2.50
Sodium sulphide, crystal, 60–62 per cent (cone)	lb.	.09 – .10	.10½ – .11
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, powdered	lb.	.17½ – .18½	.19 – .20
Sulphur chloride	lb.	.05½ –	.06 –
Sulphur, crude	ton	22.00 –	–
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.60 – .63	.65 –
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran	lb.	.13 – .13½	.13½ – .17
Zinc cyanide	lb.	.49 –	.50 – .60
Zinc dust	lb.	.12½ –	.13 – .15
Zinc oxide, U. S. P	lb.	.18 – .19	.20 – .21
Zinc sulphate	lb.	.03½ – .03½	.04 – .06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.40 —	$1.50
Alpha naphthol, refined	lb.	1.60 —	1.70
Alpha naphthylamine	lb.	.55 —	.60
Aniline oil, drums extra	lb.	.35 —	.40
Aniline salts	lb.	.40 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.90 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.35 —	1.40
Benzidine, sulphate	lb.	1.15 —	1.25
Benzoic acid, U.S.P.	lb.	.90 —	1.00
Benzoate of soda, U.S.P.	lb.	.80 —	.90
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.40
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.31
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate (nominal)	lb.	3.50 —	4.00
Beta naphthol, sublimed (nominal)	lb.	.80 —	.90
Beta naphthol, tech (nominal)	lb.	.65 —	.85
Beta naphthylamine, sublimed	lb.	2.25 —	2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 —	.19
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.10 —	1.20
Cresylic acid, 95-97%, dark, in drums	gal.	1.00 —	1.05
Cresylic acid, 50%, first quality, drums	gal.	.65 —	.75
Dichlorbenzol	lb.	.08 —	.10
Diethylaniline	lb.	1.50 —	1.60
Dimethylaniline	lb.	1.35 —	1.55
Dinitrobenzol	lb.	.30 —	.37
Dinitroclorbenzol	lb.	.30 —	.35
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.40 —	.45
Dinitrotoluol	lb.	.40 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine (nominal)	lb.	.80 —	.85
H-acid (nominal)	lb.	2.25 —	2.50
Metaphenylenediamine	lb.	1.15 —	1.30
Monochlorbenzol	lb.	.18 —	.20
Monoethylaniline	lb.	2.00 —	2.40
Naphthaline crushed, in bbls. (250 lb.)	lb.	.17 —	
Naphthaline, flake	lb.	.17 —	.18
Naphthaline, balls	lb.	.16 —	.18
Naphthionic acid, crude	lb.	.75 —	.85
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.40 —	.50
Nitro-toluol	lb.	.18 —	.25
Ortho-amidophenol	lb.	3.25 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.80 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.35 —	.45
Para-amidophenol, base	lb.	2.50 —	3.00
Para-amidophenol, HCl	lb.	2.50 —	3.00
Para-dichlor-benzol	lb.	.08 —	.12
Paranitraniline	lb.	1.50 —	1.55
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.60 —	3.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.65 —	.75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.20
Pyridin	gal.	2.00 —	3.50
Resorcin, technical	lb.	4.25 —	4.50
Resorcin, pure	lb.	6.25 —	6.75

Salicylic acid, tech., in bbls. (110 lb.)	lb.	$0.50	—	$0.52
Salicylic acid, U. S. P.	lb.	.50	—	.60
Salol	lb.	.90	—	1.00
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25	—	.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.28	—	.32
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	...
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	...
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.36	—	$0.39
Beeswax, refined, light	lb.	.39	—	.40
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1, (nominal)	lb.	1.00	—	1.05
Carnauba, No. 2, regular (nominal)	lb.	.85	—	.88
Carnauba, No. 3, North Country (nominal)	lb.	.43	—	.44
Japan	lb.	.21	—	.22
Montan, crude	lb.	.23	—	.25
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.09	—	.09½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.09½	—	.10
Paraffine waxes, refined, 118-120 m.p.	lb.	.11½	—	.12½
Paraffine waxes, refined, 128-130 m.p.	lb.	.14½	—	.15
Paraffine waxes, refined, 133-135 m.p.	lb.	.16½	—	.17
Paraffine waxes, refined, 135-137 m.p.	lb.	.17½	—	.18½
Stearic acid, single pressed	lb.	.25	—	.26
Stearic acid, double pressed	lb.	.26	—	.27
Stearic acid, triple pressed	lb.	.27	—	.28

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.60
Pine oil, pure, dest. dist.	gal.	1.63
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.50	—	$18.00
Rosin E-I	280 lb.	18.50	—	19.75
Rosin K-N	280 lb.	20.00	—	21.00
Rosin W. G.-W. W.	280 lb.	21.25	—	23.00
Wood rosin, bbl.	280 lb.	17.00	—	17.00
Spirits of turpentine	gal.	1.85		
Wood turpentine, steam dist.	gal.	1.70	—	1.80
Wood turpentine, dest. dist.	gal.	1.40	—	1.50
Pine tar pitch, bbl.	200 lb.		—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	15.00
Retort tar, bbl.	500 lb.	15.00	—	15.50
Rosin oil, first run	gal.	.87	—	.89
Rosin oil, second run	gal.	.89	—	.92
Rosin oil, third run	gal.	1.04	—	1.05
Rosin oil, fourth run	gal.	1.12	—	1.12

Solvents

76 deg., steel bbls. (85 lb.)	gal.	$0.40		
70-72 deg., steel bbls. (85 lb.)	gal.	.38		
68-70 deg., steel bbls. (85 lb.)	gal.	.37		
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.29		

Crude Rubber

Para—Upriver fine	lb.	$0.37½	—	$0.38
Upriver coarse	lb.	.28½	—	.29½
Upriver caucho ball	lb.	.30	—	.30½
Plantation—First latex crepe	lb.	.38	—	.39
Ribbed smoked sheets	lb.	.38¼	—	.39
Brown crepe, thin, clean	lb.	.37	—	.38
Amber crepe No. 1	lb.	.....	—	.40

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.18½	—	$0.20
Castor oil, AA, in bbls.	lb.	.20	—	.22
China wood oil, in bbls.	lb.	.22½	—	.23½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.17½	—	.18½
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.18½	—	.19½
Corn oil, crude, in bbls.	lb.	.17½	—	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.16½	—	.16½
Cottonseed oil, summer yellow	lb.	.19	—	.19½
Cottonseed oil, winter yellow	lb.	.21	—	.22
Linseed oil, raw, car lots (domestic)	gal.	1.57	—	1.67
Linseed oil, raw, tank cars (domestic)	gal.	1.52	—	1.62
Linseed oil, boiled, car lots (domestic)	gal.	1.60	—	1.70
Olive oil, commercial	gal.	3.10	—	3.25
Palm, Lagos	lb.	.12½	—	.13½
Palm, bright red	lb.	.13	—	.13½
Palm, Niger	lb.	.11	—	.12
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.13	—	.15
Peanut oil, refined, in bbls.	lb.	.22	—	.24
Rapeseed oil, refined in bbls.	gal.	1.70	—	1.72
Rapeseed oil, blown, in bbls.	gal.	1.80	—	1.85
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.17	—	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.12½	—	.13½

FISH

Winter pressed Menhaden	gal.	$1.17	—	$1.18
Yellow bleached Menhaden	gal.	1.20	—	1.22
White bleached Menhaden	gal.	1.23	—	1.24
Blown Menhaden	gal.	1.30	—	1.32

Miscellaneous Materials

All f. o. b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$22.00	—	$25.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	18.00	—	20.00
Barytes, crude, 88% @ 94% ba., Kings Creek	net ton	8.00	—	10.00
Barytes, ground, white, f.o.b. Cartersville, Ga.	net ton	23.00	—	25.00
Barytes, ground, off-color, f.o.b. Cartersville	net ton	16.00	—	19.00
Barytes, crude, 88% @ 94% ba., Cartersville	net ton	12.00	—	...
Blanc fixe, dry	lb.	.05½	—	.06
Blanc fixe, pulp	net ton	60.00	—	80.00
Casein	lb.	.15	—	.18
Chalk, domestic, extra light	lb.	.05	—	.06
Chalk, domestic, light	lb.	.04½	—	.05
Chalk, domestic, heavy	lb.	.04	—	.05
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.05	—	.06
Chalk, English, dense	lb.	.04½	—	.05
China clay (Kaolin) crude f.o.b. Virginia points	net ton	8.00	—	12.00
China clay (Kaolin) ground, f.o.b. Virginia points	net ton	15.00	—	40.00
China clay (Kaolin), imported, lump	net ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	net ton	30.00	—	60.00
Feldspar (nominal) f.o.b. N. Y. State	net ton	16.00	—	20.00
Feldspar, crude, f.o.b. Maryland and North Carolina, points	net ton	7.50	—	8.00
Feldspar, ground, f.o.b. Baltimore	net ton	22.00	—	25.00
Feldspar, ground, f.o.b. North Carolina	net ton	16.00	—	20.00
Fuller's earth, granular, f.o.b. Fla.	net ton	25.00	—	
Fuller's earth, powdered, f.o.b. Fla.	net ton	18.00	—	
Fuller's earth, imported, powdered	net ton	35.00	—	40.00
Graphite (dust polish grade 30%) Ashland, Ala	lb.	.....	—	.01
Graphite (dust facing grade 50%) Ashland, Ala	lb.	.....	—	.02
Graphite, crucible, 80% carbon Ashland, Ala	lb.	.....	—	.05
Graphite, crucible, 90% carbon Ashland, Ala	lb.	.....	—	.10
Graphite, crucible, 85% carbon	lb.	.....	—	.08
Graphite, crucible, 88% carbon	lb.	.....	—	.09½
Graphite, crucible, 90% carbon	lb.	.....	—	.10½
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton	.....	—	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	.....	—	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	.....	—	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00	—	7.50
Shellac, orange, fine	nominal lb.	1.40	—	...
Shellac, orange, superfine	lb.	1.50	—	...
Shellac, N. C. garnet	lb.	1.10	—	1.15
Shellac, T.N.	lb.	1.15	—	1.25
Soapstone	ton	15.00	—	25.00
Talc, paper-making grades, f.o.b. Vermont	ton	9.50	—	14.00
Talc, roofing grades, f.o.b. Vermont	ton	8.00	—	9.00
Talc, rubber grades, f.o.b. Vermont	ton	9.00	—	15.00
Talc, powdered, Southern, f.o.b. cars	ton	12.00	—	15.00
Talc, talcum powder grade, California	ton	20.00	—	35.00
Talc, imported	ton	60.00	—	70.00

Refractories

Following prices are f.o.b. Works:

Chrome brick, 9 in. straights and sizes	net ton	$80-90 at Baltimore
Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Fire clay, f.o.b. Baltimore	net ton	$5—7
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	85-90 at Chester, Penn.
Magnesite brick, 9 in. straights	net ton	90 at Baltimore
Magnesite brick, 9 in. sizes and shapes larger than 9 in.		Regular extras
Silica brick	1,000	50-55 at Mt. Union, Penn.
Silica brick, 9 in. and 9 in. sizes	1,000	55, Chicago District

Ferro-Alloys

All Prices f. o. b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.17	—	.18
Ferro-chrome, per lb. of Cr. contained, 4-6% carbon	lb.	.18	—	.19
Ferro-manganese, 70-80% Mn.	gross ton	200.00	—	250.00
Spiegeleisen, 16-20% Mn.	gross ton	72.50	—	75.00
Ferro-molybdenum, per lb. of Mo.	lb.	2.25	—	2.75
Ferro-silicon, 10-15%	gross ton	60.00	—	65.00
Ferro-silicon, 50%	gross ton	80.00	—	90.00
Ferro-silicon, 75%	gross ton	150.00	—	160.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90	—	1.10
Ferro-uranium, 35-50% of U, per lb. of U content	lb.	7.00	—	...
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50	—	7.75

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 40%, min., Cr_2O_3 f.o.b. Atlantic Seaboard	unit	$0.70	—	$0.85
Coke, foundry, f.o.b. ovens	net ton	16.00	—	16.50
Coke, furnace, f.o.b. ovens	net ton	15.00	—	15.50
*Petroleum coke, refinery, Atlantic seaboard	net ton	.....	—	24.00
Fluor spar, gravel, f.o.b. mines	net ton	22.50	—	25.00
Fluor spar, lump, f.o.b. Tonuco, New Mexico	net ton	17.50	—	...
Manganese ore, 45% Mn and over	unit	.80	—	.85
Manganese ore, chemical (MnO_2)	gross ton	75.00	—	85.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.85	—	....
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00	—	....
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	7.50
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Vanadium Ore per lb. of V contained	lb.	1.00	—	3.00
Pyrites, foreign, lump, per unit of S contained	unit	.16½	—	.....
Pyrites, foreign, fine, per unit of S contained	unit	.16½	—	.....
Pyrites, domestic, fine, per unit of S contained	unit	.16	—	.17½
Ilmenite, 52% TiO_2, per lb. ore	lb.	.02	—	...
Rutile, 95% TiO_2 per lb. ore	lb.	.20	—	.25
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	.....
Monazite, per unit of ThO_2	unit	42.00	—	.....

*Nominal

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

STEGE—The Stauffer Chemical Co. is building a modern sulphuric acid plant here. The plant will have a daily capacity of 40 tons of concentrated acid. Estimated cost, $1,000,000.

Colorado

JOHNSTOWN—The Great Western Sugar Co., Sugar Bldg., Denver, has purchased a site here and is having plans prepared for the construction of a factory on same. Estimated cost, $2,000,000.

Connecticut

NEW LONDON — The United States Electric Co., 108 State St., has awarded the contract for the construction of a 75x101-ft. foundry for the manufacture of electric riveter and heater, at 21 Trumbull St., to A. T. Jackson & Co., 108 State St. Estimated cost, $50,000.

Idaho

JEROME—The Bd. of Trustees for the Independent School Dist. 33, will soon award the contract for the construction of a high school. Chemical and physical laboratories will be installed in same. Oliver Hill, clk.

Illinois

ASHLAND—School Dist. 212 has awarded the contract for the construction of a 1-story, 105x180-ft. high school, to C. H. Schenk, 2068 South 5th St., Springfield, at $110,000. Experimental laboratory equipment will be installed in same.

MONTICELLO—The Bd. Educ. is having plans prepared for the construction of a 2-story, 110x192-ft. high school here. A small chemical laboratory will be installed in same. Estimated cost, $200,000. J. C. Llewellyn, 38 South Dearborn St., Chicago, archt.

WAGGONER — The Community High School Bd. plans to construct a high school here. A small chemical laboratory will be installed in same. Estimated cost, $60,000. J. N. Coleman, 6257 St. Laurence St., Chicago, archt.

Indiana

SHELBYVILLE—The stockholders of the Citizens Gas Co. have voted in favor of the construction of an artificial gas plant here.

Iowa

DES MOINES—The Des Moines Fdry. & Machine Co., 314 Flynn Bldg., has awarded the contract for the construction of a 1-story, 130x220-ft. foundry and machine shop on 16th St. and Wabash Ave., to F. D. Chase, Inc., 17 Battery Pl., New York City. Estimated cost, $350,000.

Kansas

NORTON—The city has awarded the contract for the construction of an addition to the sewage treatment plant, powerhouse, dam, etc., to Green & Rickey.

Kentucky

STURGIS—The Bd. Educ. has awarded the contract for the construction of a high school here, to J. N. Boston & Son, Marion, Ky. A chemical laboratory will be installed in same. Estimated cost, $45,000.

Maine

BIDDEFORD—The Saco-Lowell Shop, 77 Franklin St., Boston, has awarded the contract for the construction of a 1-story, 160x200-ft. foundry, to the Aberthaw Constr. Co., 27 School St., Boston, at $250,000.

Maryland

BALTIMORE — The LaMotte Chemical Products Co., 13 West Saratoga St., plans to construct two 1-story laboratories. The company is in the market for earthenware, filters, crystallization vats, vacuum pumps, laboratory and general equipment. F. L. LaMotte, pres. and mgr.

BALTIMORE — The Prest-O-Lite Co., Inc., 30 East 42nd St., New York City, will soon award the contract for a 1-story, 25x50-ft. acetylene plant in connection with the 8 proposed acetylene buildings here. Estimated cost, $75,000.

FREDERICK — The Frederick County School Comrs. have awarded the contract for the construction of a 2-story high school addition, to L. C. Culler, Knights of Pythias Bldg. Plans include a chemical laboratory, machine shop, etc.

SPARROW'S POINT (Baltimore P. O.) —The Bethlehem Steel Corp. plans to increase its unit here. New blast furnaces will be installed and the capacity of the present tin plate plant will be doubled by the addition of 24 mills. Eugene G. Grace, pres.

Massachusetts

GARDNER—The Amer. Fibre Corp. has awarded the contract for the construction of a 1-story fiber manufacturing plant on Coleman St., to N. E. Frissul, at $75,000.

Michigan

BAY CITY—The Wildman Rubber Co., Book Bldg., Detroit, is having plans prepared for the construction of a 1- and 3-story rubber manufacturing building. Estimated cost, $2,000,000. Osborn Eng. Co., 2848 Prospect Ave., Cleveland, O., archt. and engr.

GRAND RAPIDS—The Oliver Machinery Co., 1025 Coldbrook St., N. E., will build a 1-story foundry addition on Coldbrook St. Foundry equipment will be installed in same. Estimated cost, $50,000. Work will be done by day labor.

New Jersey

NEWARK—Max Hertz, 68 Oliver St., has awarded the contract for the construction of a 1-story factory addition for the manufacture of leather at 74 Oliver St., to J. W. Ferguson Co., United Bank Bldg., Paterson. Estimated cost, $20,000.

TRENTON — The Bergounan Rubber Corp., East State St., is in the market for $60,000 worth of machinery for plant now being constructed. Herbert Coleman, pres.

TRENTON—The John E. Thropp Sons Co., Fair St., has awarded the contract for the construction of a 1-story, 150x160-ft. foundry on Fair St., to the Austin Co., Bulletin Bldg., Philadelphia, Pa. Estimated cost, $36,000.

New York

BROOKLYN—Henry Holder, archt. and engr., 242 Franklin Ave., plans to construct a 1-story, 100x250-ft. foundry. Estimated cost, $250,000. Owner's name withheld.

BUFFALO—The Jacob Dold Packing Co., 745 William St., had plans prepared for the construction of a tank house and a fertilizer building. Estimated cost, $250,000.

TONAWANDA—The Bd. of Pub. Works has commissioned Chester & Fleming, consult. engrs., Union Bank Bldg., Pittsburgh, Pa., to make a report on the sewerage and sewage disposal systems for the city.

Ohio

RAVENNA — The Natl. Furnace Stove Co. is having plans prepared for the construction of a 1-story, 80x220-ft. office and foundry building. Estimated cost, $125,000. M. Minsman, mgr. D. C. Smith, 4500 Euclid Ave., Cleveland, archt. and engr.

Pennsylvania

BLAIRSVILLE — The Western State Hospital for the Insane plans to construct a sewage disposal plant, reservoir, hospital buildings, etc., at Torrance, near here.

PHILADELPHIA—The Surpass Leather Co., 9th and Westmoreland Sts., plans to build a 1-story, 40x50-ft. factory addition on 19th and Ontario Sts. Estimated cost, $10,000.

WILKES BARRE — The Wilkes-Barre Bertels Tin Co., Pennsylvania Ave., plans to build a 2-story, 70x75-ft. tin factory. Estimated cost, $30,000.

South Carolina

CAYCE—The Seminole Fertilizer & Oil Co., Jacksonville, Florida, has purchased site here and had plans prepared for the construction of a fertilizer and mixing plant here. Noted May 19.

Texas

ALPINE—B. F. Berkeley, mayor, will soon award the contract for furnishing material and labor including a sedimentation tank, etc., for the construction of a sewer system for the city.

Virginia

MARTINSVILLE—S. G. Whittle, Jr., will receive bids until July 15 for the construction of a 2-story high school here. A chemical laboratory will be installed in same. W. C. Northup, Winston-Salem, N. C., archt.

RICHMOND—The Gould Fire Prevention Products Co., 215 Travelers Bldg., is in the market for full equipment for manufacturing oil, lead and zinc paints.

Washington

VALLEY—The Amer. Mining Production Co. is building a kiln, etc., for the treatment of magnesite. Estimated cost, $50,000. Howard F. Wierum, engr.

Wisconsin

APPLETON — St. Elizabeth Hospital plans to build a 4-story hospital. A chemical laboratory will be installed in same. Estimated cost, $500,000. Address Franciscan Sisters.

BEAVER DAM—The F. Kassman Mfg. Co. plans to build a 1-story, 60x120-ft. molding foundry addition on Main St.

CORNELL—The Cornell Wood Products Co. has awarded the contract for the construction of a 2-story, 44x320-ft. paper making plant here, to W. E. Uhle, Stevens Point. Estimated cost, $1,000,000.

PORT WASHINGTON — The Turner Mfg. Co. is having plans prepared for the construction of a 1-story foundry here. Estimated cost, $50,000. F. D. Chase, Inc., 645 North Michigan Ave., Chicago, engr.

RACINE—S. C. Johnson & Son, 1012 Sixteenth St., rejected bids for the construction of a 4-story, 60x160-ft. warehouse and varnish plant. Work will be readvertised. Noted June 9.

WAUKESHA—F. C. Blair & Son, 340 B'way, plans to build a 1-story foundry.

Wyoming

SHOSHONI — The Wyoming Chemical Products Co., Duluth, Minn., plans to build a plant including several buildings for the manufacture of alum and epsom salts from the natural deposits near Shoening Siding along the Chicago, Burlington & Quincy R.R. Estimated cost, $200,000. The company is in the market for 2 triple effect evaporators, drying equipment, etc. W. G. Wey, engr.

Ontario

BRANTFORD — S. C. Johnson & Son, Racine, Wis., is having plans prepared for the construction of a factory to manufacture floor waxes, varnishes, etc.

TORONTO—The Bd. Educ., College St., plans to construct a 3-story technical school including chemical laboratory equipment, etc. Estimated cost, $400,000. Address Dr. McKay, Central Technical School, College St.

TORONTO—The Canada Creosoting Co., 1006 Canadian Pacific R.R. Bldg., plans to construct a plant and is in the market for creosoting cylinders, etc. Estimated cost, $150,000.

Quebec

MONTREAL—The Natl. Drug Co., St. Laurence St., will soon receive bids for the construction of a plant in the St. Henry Dist. Estimated cost, $175,000.

MONTREAL—The Phillips Electrical Co., Craig St., West, has awarded the contract for the construction of a 2-story, 40x60-ft. factory for the manufacture of electrical goods, on Henri Julien St., to Nicholson Co., St. Catharine St., West, at $22,000.

ST. ANNE DE MONTS—The Great Eastern Pulp & Paper Co., London, Great Britain, plans to build a pulp and paper plant here.

SHAWINIGAN FALLS—The Northern Aluminum Co. will soon receive bids for the construction of an office building and is in the market for laboratory equipment.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept. 7 to 10 inclusive.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its twelfth semi-annual meeting as follows: June 28 and 29 will be spent in Montreal, June 30 in Ottawa, July 1 in Ontario, July 2 in Shawinigan Falls, July 3 in La Tuque, July 4 in Chicoutimi and July 5 in Quebec.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its one hundred and twenty-second meeting Aug. 20 to Sept. 3, at Lake Superior.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at the New Monterey Hotel, Asbury Park, N. J., June 22 to 25.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18 inclusive.

THE FOREST PRODUCTS LABORATORY will hold its decennial celebration at Madison, Wis., July 22 and 23, 1920.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE INSECTICIDE AND DISINFECTANT MANUFACTURERS' ASSOCIATION will hold its mid-summer meeting at Boston, July 15 and 16.

THE IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE ILLINOIS MINING INSTITUTE will meet in Chicago, June 23 to 26.

THE STEEL BARREL MANUFACTURERS' ASSOCIATION will meet in Chicago, June 24.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its fall meeting at Saratoga Springs, N. Y., Sept. 1, 2 and 3.

Industrial Notes

THE ELECTRIC FURNACE CONSTRUCTION CO., Philadelphia, Pa., announces that George P. Mills, formerly electrical sales engineer of the General Electric Co., Philadelphia, has joined the staff, to take charge of and specially develop electrical industrial heating furnaces.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO. at the annual meeting of stockholders, held at East Pittsburgh, Pa., June 9, re-elected the following directors for three years: Guy E. Tripp, chairman of the board of directors of the Westinghouse Electric & Manufacturing Co., New York City; Joseph Marsh, president of the Standard Underground Cable Co., Pittsburgh, Pa.; H. H. Westinghouse, chairman of the board, Westinghouse Air Brake Co., New York City; Albert H. Wiggin, chairman of the board of the Chase National Bank of New York. George W. Davison, president of the Central Union Trust Co. of New York City, who was selected by the board of directors to succeed James N. Wallace, deceased, was elected by the stockholders for the term expiring June, 1921. The election was decided by the largest number of votes (personal or proxy) ever cast in the history of the company. This company also announces that G. B. Rosenblatt, who specializes in the commercial and technical activities in the West with respect to metal mining and smelting, coal mining and oil, and electrometallurgical and electrochemical industries, has moved his headquarters from the Salt Lake City office to the San Francisco office.

HAMILTON & HANSELL, INC., of New York City, has moved its offices to 15-21 Park Row, New York City. N. V. Hansell is president, H. A. DeFries vice-president, and J. Herlenius treasurer-secretary.

THE CHEMICAL CONSTRUCTION CO., New York City, has moved its New York office from 30 East 42nd St. to 51 East 42nd St.

THE MERRILL CO., San Francisco, Cal., announces that it is now prepared to deliver standard sizes of the Merco Nordstrom Plug Valve from the plant of the Swenson Evaporator Co. at Angola, Ind., which is now manufacturing these products for the Merrill Co. Inquiries regarding the valve and orders for the valve can be handled by the Chicago office, and Eastern consumers will save considerable in freight as well as in time of delivery, if orders are placed there.

THE RESEARCH CORP., New York City, has just opened up an office in Chicago at 76 West Monroe St. H. M. Pier, at present commercial representative, will be Chicago district representative.

WILLIAM C. REDFIELD, formerly Secretary of Commerce of the United States and now president of the American-Russian Chamber of Commerce, spoke before the civic industrial committee, Chicago, recently on business conditions in Russia.

THE INDUSTRIAL TRACK CONSTRUCTION CO. of St. Louis has established a branch office in Memphis, Tenn., headquarters in the Randolph Bldg. This company specializes on industrial track layouts. H. A. Nims is general manager.

THE LAKEWOOD ENGINEERING CO., Cleveland, O., has established branch offices in the Central Bank Bldg., at Memphis, Tenn. C. F. McArdle will be in charge of the territory.

S. F. BOWZER & CO., INC., of Fort Wayne, Ind., has appointed A. B. Carriger district manager, Falls Bldg., Memphis, Tenn.

WILLIAM D. EDWARDS, of Chicago, has established a consulting engineering office at 116 South Front St., Memphis, Tenn. The mechanical features of industrial drying and dehydrating plants in the fertilizer business and allied industries will be dealt with.

THE LOWE BROS CO., paint and varnish manufacturer of Dayton, Ohio, has established a branch sales office at Shelby and Nettleton Sts., Memphis, Tenn.

DR. OTTO K. ZWINGENBERGER has moved his offices from 13 Park Row to 38 Park Row, New York City.

THE INTERNATIONAL OXYGEN CO., of Newark, N. J., announces that Eugene Schoen, general manager, has sailed for Europe to make an inspection of the company's branches in London and Paris, and to extend the business of the company in France, England, Belgium, Germany, Switzerland, Sweden and Denmark, where reconstruction following the war has stimulated the demand for oxygen and hydrogen-generating apparatus.

THE BUR-MAC CORP., 1 Liberty St., New York, has been organized as a dealer in industrial chemicals, particularly used in textile, paper, tanning, soap and chemical manufacturing. Swen Ringborg is president, M. E. McGovern vice-president, and W. R. Burrows treasurer.

THE MERRILL CO. has retained the services of W. H. Campbell as auditor of the Chicago office. Mr. Campbell was recently connected with the Government food administration.

THE AMERICAN BLUE PRINT PAPER CO., 455 Plymouth Court, Chicago, has developed the Baker process for making duplicate waterproof tracings. The lines of the Baker prints are photographed on chemically prepared surfaces—tracing cloth, paper or other pliable material. The duplicate tracings are covered with waterproofing and the lines are actually produced in the waterproof coating. Corrections on the duplicates are made quickly because the lines erase very easily. This process is very convenient where a full drawing would necessarily have to be retraced on account of changing just a small portion or detail. A duplicate Baker print can be made having any desired portion left out, after which the change in details can be inserted, thus producing a new tracing with minimum cost.

THE WESTERN FOUNDRY CO., Chicago, has purchased a 3-acre plant at the corner of Wentworth Ave. and 16th St., Chicago Heights, to be used as an addition to its manufacturing operations.

THE ILLINOIS TOOL CO. of Chicago has secured a new building at the northwest corner of Erie and St. Claire Sts., for use as a general sales room, office and manufacturing plant to produce a large variety of tools.

THE WATERBURY CO. of New York, manufacturer and dealer in wire and manilla rope, has opened a Chicago branch at 609 North LaSalle St.

THE LAMBERTSON JAPANNING WORKS will occupy a 1-story building at 4010 North Claremont Ave., Chicago.

THE COLOMBIAN COMMERCIAL CORP., LTD., Earl Harding, president, 54 Dey St., New York City, has been organized to develop trade with Colombia from an international viewpoint. It offers its services to manufacturers of North America in developing a market for merchandise in Colombia and importing raw materials therefrom. Manufacturers interested in this country can secure a complimentary copy of the *Colombian Review* on application to the corporation.

THE AFFILIATION of Westinghouse, Church, Kerr & Co. and Dwight P. Robinson & Co., Inc., which was announced some time ago, is to be known until the completion of the merger as the Westinghouse, Church, Kerr & Co., Inc. Offices have been moved from 37 Wall St. to 125 East 46th St., New York City.

THE EASTON CAR & CONSTRUCTION CO. has removed its general offices from 30 Church St. to larger quarters in 50 Church St., New York City.

THE AMERICAN METALLURGICAL CORP., Philadelphia, announces the closing of a contract with the Thermoid Rubber Co., Trenton, N. J., for the installation of electric oven equipment to take care of the production of a special processed product to be placed on the market by this company. The installation involves a number of new principles specially pertaining to solvent recovery and automatic control of heat temperatures.

THE E. I. DU PONT DE NEMOURS POWDER CO. has declared the regular quarterly dividend of 1¼ per cent on the common and 1¾ per cent on the preferred stock, payable Aug. 2 to stock of record July 20.

E. I. DU PONT DE NEMOURS & CO. declared quarterly dividends of 4½ per cent on the common, payable $2 in cash and $2.50 in common stock and 1¾ per cent on debenture. Common is payable June 15 to stock of record of May 29 and debenture July 20 to stock of record July 10.

THE U. S. INDUSTRIAL ALCOHOL CO. has declared a dividend of $2 a share for the second quarter of the year 1920 on the common capital stock of the company, payable June 15, 1920, to stockholders of record June 1, 1920.

THE UNION CARBIDE & CARBON CORP. has declared a quarterly dividend of $1.50 payable July 1 to stock of record June 10. Previously it paid $1.25 quarterly.

THE CENTRAL LEATHER CO. has declared a regular quarterly dividend of 1¾ per cent on the preferred stock, payable July 1 to stock of record June 10.